10/031181 JC10 Rec'd PCT/PTO 16 JAN 2002

FORM PTO-1390 (REV 12-2001) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: 3333/1/US

U S APPLICATION NO (If known, see 37 CFR 1.5): 10/031181

INTERNATIONAL APPLICATION NO	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/US00/16323	July 12, 2000	July 16, 1999

TITLE OF INVENTION: Method of Changing Conformation of a Matrix Metalloproteinase

APPLICANT(S) FOR DO/EO/US: Stallings et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [x] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [x] This is an express request to begin national examination procedures (35 U S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [ ] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [x] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [x] is attached hereto (required only if not communicated by the International Bureau).
   b [ ] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [ ] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [ ] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [x] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [x] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [ ] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [ ] Other items or information:

U.S. APPLICATION NO (If known, see 37 CFR 1.5) 10/031181	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER

21. [x] The following fees are submitted:

	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	64 - 20 =	44	x **$18.00**	$ 792.00	
Independent claims	4 - 3 =	1	x **$84.00**	$ 84.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$280.00**	$	
TOTAL OF ABOVE CALCULATIONS =				$ 1766.00	
[ ] Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +				$	
SUBTOTAL =				$ 1766.00	
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$	
TOTAL NATIONAL FEE =				$ 1766.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
TOTAL FEES ENCLOSED =				$ 1766.00	
				Amount to be refunded:	$
				charged:	$

a. [x] A check in the amount of $ 1766.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [x] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 08-0750 . A duplicate copy of this sheet is enclosed.

d. [ ] Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Philip Polster, Reg. No. 43,864
Corporate Patent Department
Mail Zone 04E
Pharmacia Corporation
800 N. Lindbergh
St. Louis, Missouri 63167

SIGNATURE

David M. Gryte
NAME

41,809
REGISTRATION NUMBER

Attorney Docket No. 3333/1/US
Client Docket No. 6794-000025/US

#2/a

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of: William C. Stallings, et al.
Serial No: Not yet assigned
Filed: January 16, 2002
For: METHOD OF CHANGING CONFIRMATION OF A MATRIX METALLOPROTEINASE
Group Art Unit: Not yet assigned
Examiner: Not yet assigned
This is national-phase application of PCT Patent Application No. PCT/US00/16323 (Int'l Filing Date July 12, 2000; WIPO Int'l Publ. No. WO 01/05389; Int'l Publ. Date January 25, 2001)
Attorney Docket Number 3333/1/US

January 16, 2002

PRELIMINARY AMENDMENT

TO THE COMMISSIONER OF PATENTS AND TRADEMARKS,
SIR/MADAM:

The above-referenced patent application (enclosed herewith) is a national-phase application of PCT Patent Application No. PCT/US00/16323. Applicants request that this Preliminary Amendment be entered into the above-referenced divisional application.

IN THE SPECIFICATION

Please replace lines 6-9 on page 1 with the following text:

This patent claims priority as a national-phase application of PCT Patent Application No. PCT/US00/16323 (Int'l Filing Date July 12, 2000; WIPO Int'l Publ. No. WO 01/05389; Int'l Publ. Date January 25, 2001 (in English)), which, in turn, claims priority to U.S. Provisional Patent Application Serial No. 60/144,133 (filed July 16, 1999). The entire texts of both those patent applications are incorporated by reference into this patent.

Please add Figures 1-16 enclosed with this amendment.

REMARKS

I. Amendments to the Specification

In accordance with 37 CFR §1.78 and MPEP §202.01, the text at the beginning of the specification has been amended to identify the PCT application to which this patent application is claiming priority.

The specification also has been amended to include Figures 1-16 enclosed herewith. Those figures are described in the specification at, for example, page 11. Although the figures were included with U.S. Provisional Application Serial No. 60/144,133, they were apparently inadvertently not included with PCT Application No. PCT/US00/16323. The PCT application, however, claims priority to the provisional application. Thus, Applicants believe that the figures do not constitute new matter in this national phase application. *See* MPEP §§ 608.01(p) and 2163.03.

II. Correspondence Address

All future correspondence for this application should be addressed to:

Phil Polster, PTO Reg. No. 43,864
Corporate Patent Department
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800 N. Lindbergh
St. Louis, Missouri 63167

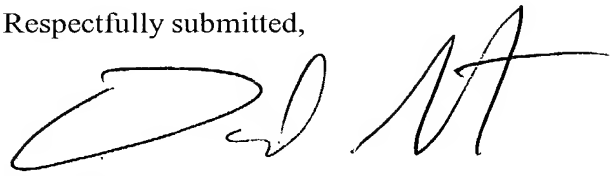
* * * * * * * * *

In view of the foregoing amendments and remarks, Applicants submit that the application is in condition for allowance.

A check is enclosed to cover the filing fee for this application. If there is ever a deficiency or an overpayment under 37 C.F.R. 1.16 or 1.17 in connection with this patent application, the Commissioner is hereby authorized to charge such deficiency or overpayment to Deposit Account No. **08-0750**.

The Examiner is requested to call the undersigned if any questions arise that can be handled over the phone to expedite examination of this application.

Respectfully submitted,



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Attorney Docket No. 3333/1/US
Client Docket No. 6794-000025/US

CERTIFICATE OF MAILING

I certify that this **Preliminary Amendment** is being deposited in the United States Postal Service as **Express Mail** in a package addressed to: **BOX PCT, Commissioner for Patents, U.S. Patent and Trademark Office, Washington, D.C., 20231** on **January 16, 2002**.

Lana B. Ekiss

DMG/LE
enclosures

Method of Changing Conformation of a Matrix Metalloproteinase

BACKGROUND OF THE INVENTION

This application claims priority of U.S. Provisional Patent Application Serial No. 60/144,133, filed July 16, 1999

Field of the Invention

This invention relates to matrix metalloproteinase enzymes, inhibitors of matrix metalloproteinase enzymes, and to methods of changing the conformation of matrix metalloproteinase enzymes.

Description of Related Art

Connective tissue, extracellular matrix constituents, and basement membranes are required components of all mammals, including humans. These components are the biological materials that provide rigidity, differentiation, attachments, and, in come cases, elasticity to biological systems. Connective tissue components include, for example, collagen, elastin, proteoglycans, fibronectin, and laminin. These biochemicals make up or are components of structures such as skin, bone, teeth, tendons, cartilage, basement membranes, blood vessels, cornea, and vitreous humor.

Under normal conditions, connective tissue turnover or repair processes are controlled and in equilibrium. The loss of this balance for whatever reason leads to a number of disease states. Inhibition of the enzymes responsible for loss of equilibrium provides a control mechanism for this tissue decomposition and, therefore, a treatment for these diseases.

Degradation of connective tissue or connective tissue components is carried out by the action of proteinase enzymes released from resident tissue cells or invading inflammatory or tumor cells. A major class of enzymes involved in this function includes the matrix metalloproteinase (MMP) enzymes. The MMPs are the subject of extensive study because of their potential involvement in disease mechanisms. Parks and Mecham have extensively reviewed the MMPs (Matrix Metalloproteinases, W.C. Parks and R.P. Mecham, ed., Academic Press, San Diego (1998)).

The MMPs are divided into classes with some members having several different names in common use. Examples are: collagenase I (MMP-1, fibroblast collagenase, EC 3.4.24.3); collagenase II (MMP-8, neutrophil collagenase, EC 3.4.24.34); collagenase III (MMP-13); stromelysin 1 (MMP-3, EC 3.4.24.17); stromelysin 2 (MMP-10, EC 3.4.24.22); proteoglycanase; matrilysin (MMP-7, EC 3.4.25.33); gelatinase A (MMP-2, 72 kDa gelatinase, EC 3.4.24.24); gelatinase B (MMP-9, 92 kDa gelatinase, EC 3.4.24.35); stromelysin 3 (MMP-11); metalloelastase (MMP-12, HME, human macrophage elastase, EC 3.4.24.65); MT1-MMP (MMP-14); MT2-MMP (MMP-15); MT3-MMP (MMP-16); and MT4-MMP (MMP-17).

The uncontrolled breakdown of connective tissue by MMPs is a feature of many pathological conditions. Examples include rheumatoid arthritis, osteoarthritis, septic arthritis, ulcerations (such as corneal, epidermal, or gastric ulcerations), periodontal disease, proteinuria; Alzheimer's Disease, coronary thrombosis, psoriasis, aneurysm, and bone disease. Defective injury repair processes also occur. This can produce improper wound healing leading to weak repairs, adhesions, and scarring. These latter defects can lead to disfigurement and/or permanent disabilities as with post-surgical adhesions.

MMP-8 (also known as neutrophil collagenase) has been shown to degrade type II collagen and aggrecan (a structural glycosaminoglycan found in the cartilage). MMP-8 has been found to be present in patients having osteoarthritis and rheumatoid arthritis and may participate significantly in the progression of these diseases. Matrix Metalloproteinases, W.C. Parks and R.P. Mecham, ed., Academic Press, San Diego (1998), pp. 32-33.

MMPs are also involved in the biosynthesis of tumor necrosis factor (TNF). Inhibition of the production or action of TNF and related compounds is a useful clinical disease treatment mechanism. TNF-α, for example, is a cytokine that is believed to be produced initially as a 28 kDa cell-associated molecule. It is released as an active, 17 kDa form that can mediate many deleterious effects *in vitro* and *in vivo*. For example, TNF can cause or contribute to the effects of inflammation, rheumatoid arthritis, autoimmune disease, multiple sclerosis, graft rejection, fibrotic disease, cancer, infectious diseases, malaria, mycobacterial infection, meningitis, fever, psoriasis, cardiovascular/pulmonary effects (such as post-ischemic reperfusion injury, congestive heart failure hemorrhage, coagulation, and hyperoxic alveolar injury), radiation damage, and acute phase responses like those seen with infections and sepsis during shock such as septic shock and hemodynamic shock. Chronic disease of active TNF can cause cachexia and anorexia. Chronic release of TNF can be lethal.

TNF-α convertase is a metalloproteinase involved in the formation of active TNF-α. Inhibition of TNF-α convertase inhibits production of active TNF- a. Some compounds that inhibit TNF-α convertase and MMPs involved in TNF-α biosynthesis are disclosed in PCT Patent Application No. WO 94/24140. Additional

compounds that inhibit such enzymes are disclosed in PCT Patent Application No. WO 94/02466. Further inhibitors are disclosed in PCT Patent Application No. WO 97/20824.

Some compounds that inhibit certain MMPs have been shown to also inhibit the release of TNF (Gearing et al., *Nature*, 376, 555-557 (1994)). McGeehan et al. disclosed further compounds which inhibit MMPs and inhibit the release of TNF (*Nature*, 376, 558-561 (1994)). There remains a need for effective MMP and TNF-α convertase-inhibiting agents.

MMPs are involved in other biochemical processes as well. Included are the control of ovulation, post-partum uterine involution, possibly implantation of fertilized ova, cleavage of APP (β-Amyloid Precursor Protein) to the amyloid plaque and inactivation of α_1-protease inhibitor (α_1-PI). Inhibition of these metalloproteinases permits, for example, the control of fertility and the treatment or prevention of Alzheimer's Disease. In addition, increasing and maintaining the levels of an endogenous or administered serine protease inhibitor drug or biochemical such as α_1-PI supports the treatment and prevention of diseases such as emphysema, pulmonary diseases, inflammatory diseases, and diseases of aging such as loss of skin or organ stretch and resiliency.

Inhibition of selected MMPs can also be desirable in other instances. For example, selective inhibition of MMP-3, MMP-2, MMP-9, or MMP-13 in the presence of MMP-1 may be useful for the treatment of cancer, prevention of metastasis of cancer cells, or the inhibition of angiogenesis. A therapy which does not inhibit MMP-1 but does selectively inhibit one or more of the other MMPs can have a therapeutically useful profile.

Osteoarthritis, another prevalent disease wherein it is believed that cartilage degradation in flamed joints is at least partially caused by MMP-13 released from cells such as stimulated chrondrocytes, may be best treated by administration of drugs which selectively inhibit MMP-13. See, for example, Mitchell et al., *J. Clin. Invest.*, 97, 761-768 (1996). See also Reboul et al., J. Clin. Invest., 97, 2011-2019 (1996).

Some inhibitors of MMPs are known. Examples include natural biochemicals such as tissue inhibitor of metalloproteinase (TIMP), a_2-macroglobulin, and their analogs or derivatives. These are high molecular weight protein molecules that form inactive complexes with metalloproteinases.

Some smaller peptide-like compounds that inhibit MMPs have also been described. Thiol group-containing amide or peptidyl amide-based metalloproteinase (MMP) inhibitors are known as is shown in, for example, PCT Patent Application No. WO 95/12389. Further such inhibitors are described in PCT Patent Application No. WO 97/24117. Still further such inhibitors are shown in U.S. Patent Application No. 4,595,700. Hydroxamate group-containing MMP inhibitors are disclosed in a number of individual patent applications such as each of the following:

WO 95/29892.

WO 97/24117.

EP 0 780 386.

WO 90/05719.

WO 93/20047.

WO 95/09841.

WO 96/06074.

Swartz et al. disclose some peptidomimetic MMP inhibitors in *Progr. Med. Chem.*, 29, 271-334 (1992). Further peptidomimetic MMP inhibitors are disclosed by Rasmussen et al., in *Pharmacol. Ther.*, 75(1), 69-75

(1997). Denis et al., disclose further peptidomimetic MMP inhibitors in *Invest. New Drugs*, 15(3), 175-185 (1997).

One possible problem associated with many known MMP inhibitors is that they often exhibit the same or similar inhibitory effects against each of the MMP enzymes. In other words, many known MMP inhibitors are not very selective. For example, the peptidomimetic hydroxamate known as batimastat is reported to exhibit IC_{50} values of about 1 to about 20 nanomolar (nM) against each of MMP-1, MMP-2, MMP-3, MMP-7, and MMP-9. Marimastat, another peptidomimetic hydroxamate, was reported to be another broad-spectrum MMP inhibitor with an enzyme inhibitory spectrum similar to batimastat, except that marimastat exhibits an IC_{50} value against MMP-3 of about 230 nM. (Rasmussen et al., *Pharmacol. Ther.*, 75(1), 69-75 (1997))

Meta analysis of data from Phase I/II studies using marimastat in patients with advanced, rapidly progressive, treatment-refractory solid tumor cancers (colorectal, pancreatic, ovarian, prostate) indicated a dose-related reduction in the rise of cancer-specific antigens used as surrogate markers for biological activity. The most common drug-related toxicity of marimastat in those clinical trials was musculoskeletal pain and stiffness, often commencing in the small joints and the hands, spreading to the arms and shoulder. A short dosing holiday of 1-3 weeks followed by dosage reduction permitted treatment to continue. (Rasmussen et al., *Pharmacol. Ther.*, 75(1), 69-75 (1997))It is thought that the lack of specificity of inhibitory effect among the MMPs may be the cause of that effect.

The primary, secondary, and tertiary structures of the MMPs have a number of characteristic features. Each MMP contains a catalytic domain which in turn comprises a zinc binding site and an adjacent site known as the

S_1' pocket. The S_1' pocket has been recognized as a major factor in substrate specificity of the MMPs. See for example B. Lovejoy et al., *Nat. Struct. Biol.*, 6 (3), 217-221 (1999) at 218. The S_1' pocket is sometimes known as the specificity pocket.

Figure 1 shows a partial sequence alignment for MMP-1, MMP-3, and MMP-8. The amino acid residues in the shaded boxes of Figure 1 comprise the residues included in the S_1' pocket for each of these MMPs. Symbols in Figure 1 identifying the amino acid residues are commonly used by those of skill in the art. The primary, secondary, and tertiary structures work together for each MMP to provide the catalytic activity, kinetics, and substrate specificity of the enzyme. These structures define the shape or conformation of the amino acid residue backbone of the enzyme. The actual sequence of amino acid residues in the S_1' pocket and the conformation of the residue backbone determine the specificity and kinetics of each MMP.

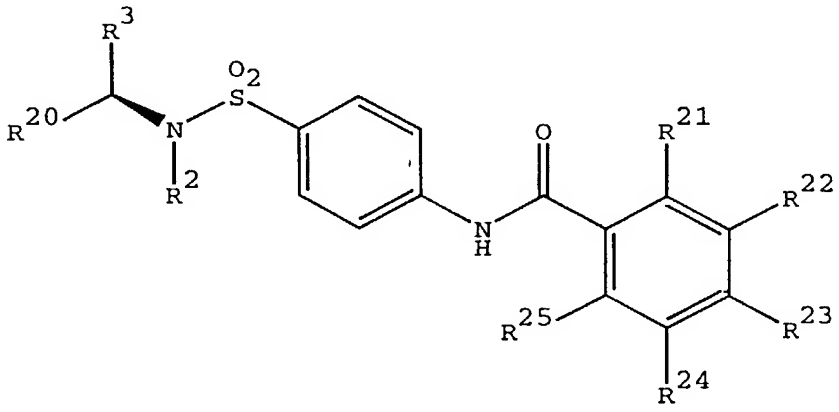
Some X-ray crystallographic experiments on MMPs are reported in the literature. For example, F. Grams *et al.* (Euro J. Biochem., 228, 830-841 (1995)) discloses X-ray structures of human neutrophil collagenase complexed with peptidomimetic hydroxamate and thiol inhibitors. In another report B. Lovejoy *et al.* (*Nat. Struct. Biol.*, 6 (3), 217-221 (1999)) disclose X-ray crystal structures of the catalytic domains of MMP-1 and MMP-13. Lovejoy *et al.* report that the MMP-1 S1' pocket undergoes a conformational change to accommodate certain diphenylether inhibitors but that the MMP-13 S1' pocket is larger and can accommodate the diphenylether inhibitors without undergoing a conformational change. They report that this difference determines the selectivity of these diphenylether compounds for preferentially inhibiting MMP-13 relative to MMP-1. The X-ray crystal structure for MMP-2 was reported by E.

Morgunova et al. ("Structure of Human Pro-Matrix Metalloproteinase-2: Activation Mechanism Revealed," *Science* **284**, 1667-1670 (1999)).

Summary of the Invention

In view of the importance of MMP inhibitors in the treatment of several diseases and the lack of enzyme specificity exhibited by two of the more potent drugs now in clinical trials, it would be a great benefit if a new method were discovered by which to inhibit one or more MMP enzymes.

Among its several embodiments, the present invention provides a matrix metalloproteinase inhibiting compound having the structure:



Formula VIII

or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof, wherein: R^2 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, and heterocycloalkylalkyl; R^3 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl,

alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, and heterocycloalkyl; R^{20} is selected from the group consisting of -C(O)OH, -C(O)NHOH, -SH, and -C(O)SH; and R^{21}, R^{22}, R^{23}, R^{24}, and R^{25} are independently selected from the group consisting of H, C_1 to about C_{20} alkyl, C_1 to about C_{20} alkenyl, C_1 to about C_{20} alkynyl, cycloalkyl, haloalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, nitroalkyl, heterocycloalkyl, and carboxyalkyl.

The invention is further directed to a method of changing the conformation of a matrix metalloproteinase wherein the method comprises contacting the matrix metalloproteinase with a compound having the formula:

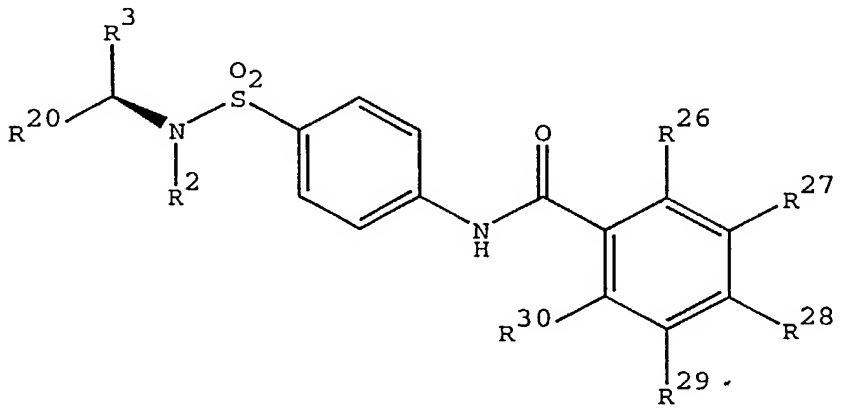


Figure XIII

or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof, thereby changing the conformation of the matrix metalloproteinase, wherein: R^2 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, and heterocycloalkylalkyl; R^3 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl,

alkylaminoalkyl, and heterocycloalkyl; R^{20} is selected from the group consisting of -C(O)OH, -C(O)NHOH, -SH, and -C(O)SH; and R^{26}, R^{27}, R^{28}, R^{29}, and R^{30} are independently selected from the group consisting of about C_3 to about C_{20} alkyl, about C_3 to about C_{20} alkenyl, about C_3 to about C_{20} alkynyl, cycloalkyl, haloalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, nitroalkyl, heterocycloalkyl, and carboxyalkyl.

The present invention is further provides a method of inhibiting a matrix metalloproteinase wherein the method comprises contacting the matrix metalloproteinase with a compound having the structure of Formula VIII or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof, thereby inhibiting the matrix metalloproteinase.

The present invention further provides a method of treating osteoarthritis in a mammal wherein the method comprises providing to the mammal an osteoarthritis-treating-effective amount of a compound having the structure of Formula VIII or an enantiomer, diastereomer, racemate, or tautomer thereof, thereby treating osteoarthritis.

Further scope of the applicability of the present invention will become apparent from the detailed description provided below. However, it should be understood that the following detailed description and examples, while indicating preferred embodiments of the invention, are given by way of illustration only since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows a partial sequence alignment for MMP-1, MMP-3, and MMP-8.

Figure 2 shows the structures of inhibitor molecules of Formulae XII, IX, X, and XI superimposed upon one another.

Figure 3 shows MMP-8 S1' amino acid backbone residues which reside within 5 Å of a complexed inhibitor molecule.

Figure 4 shows a comparison of the S1' pockets of MMP-1 and of MMP-8.

Figures 5, 6, 7, and 8 show the effect of progressively lengthening the P1' group of an MMP inhibitor on the conformation of the substituents on amino acid residues of the S1' pocket.

Figures 9, 10, 11, and 12 show the effect of progressively lengthening the P1' group of an MMP inhibitor on the conformation of the backbone of the S1' pocket.

Figure 13 shows the temperature factor (B) distribution for MMP-8 complexes with inhibitor compounds.

Figure 14 shows the (ϕ,ψ) distribution among the amino acid residues of MMP-8 from 222 to 231.

Figures 15 and 16 show electron density distributions of one aspect of the overall MMP-8 enzyme when different inhibitor compounds have been complexed.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following detailed description is provided to aid those skilled in the art in practicing the present invention. Even so, this detailed description should not be construed to unduly limit the present invention as modifications and variations in the embodiments

discussed herein can be made by those of ordinary skill in the art without departing from the spirit or scope of the present inventive discovery.

The contents of each of the references cited herein, including the contents of the references cited within these primary references, are herein incorporated by reference in their entirety.

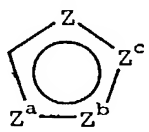
a. Definitions

The following definitions are provided in order to aid the reader in understanding the detailed description of the present invention:

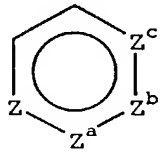
"AIkyl," "alkenyl," and "alkynyl" unless otherwise noted are each straight chain or branched chain hydrocarbons of from one to about 20 carbon atoms for alkyl or to about twenty carbon atoms for alkenyl and alkynyl. The terms therefore mean, for example, methyl, ethyl, propyl, butyl, pentyl, or hexyl; ethenyl, propenyl, butenyl, pentenyl, or hexenyl; and ethynyl, propynyl, butynyl, pentynyl, or hexynyl respectively and isomers thereof.

"Aryl" means a fully unsaturated mono- or multi-ring carbocycle, including but not limited to substituted or unsubstituted phenyl, naphthyl, or anthracenyl.

"Heterocycle" means a saturated or unsaturated mono- or multi-ring carbocycle wherein one or more carbon atoms can be replaced by N, S, P, or O. This includes, for example, the following structures:



or



wherein one or more of Z, Z^a, Z^b, or Z^c is independently C, S, P, or N, with the proviso that one of Z, Z^a, Z^b, or Z^c is other than carbon, but is not O or

S when attached to another Z atom by a double bond or when attached to another O or S atom. Furthermore, the optional substituents are understood to be attached Z, Z^a, Z^b, or Z^c only when the atom to which the optional substituent is attached is C.

"Heteroaryl" means a fully unsaturated heterocycle.

In either "heterocycle" or "heteroaryl" the point of attachment to the molecule of interest can be at the heteroatom or elsewhere within the ring.

"Cycloalkyl" means a mono- or multi-ringed carbocycle wherein each ring contains three to about ten carbon atoms, and wherein any ring can contain one or more double or triple bonds.

The term "halogen" or "halo" means a fluoro, chloro, bromo or iodo group.

The term "haloalkyl" means alkyl substituted with one or more halogens.

The term "diyl" means a diradical moiety wherein the moiety has two points of attachment to a molecule of interest.

The term "heterocycloalkylalkyl" means an alkyl radical that is substituted with one or more heterocycle groups. Preferable heterocycloalkylalkyl radicals are "lower heterocycloalkylalkyl" radicals having one or more heterocycle groups attached to an alkyl radical having one to ten carbon atoms.

When used in combination, for example "alkylaryl" or "arylalkyl," the individual terms listed above have the meaning indicated above.

b. Compounds

The compounds of the present invention can have at least two asymmetrical carbon atoms, and therefore included racemates and stereoisomers such as diastereomers and enantiomers, in both pure form and in

admixture. Such stereoisomers can be prepared using conventional techniques, either by reacting enantiomeric starting materials, or by separating isomers of compounds of the present invention.

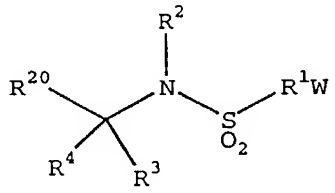
Isomers may include geometric isomers, for example cis isomers or trans isomers across a double bond. All such isomers are contemplated among the compounds of the present invention.

The compounds of the present invention also include their tautomers, salts, solvates, and prodrugs.

In accordance with the present invention, it has been discovered that certain novel substituted-aromatic sulfonamide hydroxamic acid compounds and/or novel substituted-aromatic sulfonamide carboxylic acid compounds are effective for inhibition of matrix metalloproteinases ("MMPs") believed to be associated with uncontrolled or otherwise pathological breakdown of connective tissue. In particular, it has been found that these substituted-aromatic ring sulfonamide hydroxamic acid, substituted-aromatic ring sulfinamide hydroxamic acid, substituted-aromatic ring sulfenamide hydroxamic acid compounds, substituted-aromatic ring sulfonamide carboxylic acid, substituted-aromatic ring sulfinamide carboxylic acid or substituted-aromatic ring sulfenamide carboxylic acid compounds are effective for inhibition of collagenase Type III (MMP-13) and neutrophil collagenase (collagenase II, MMP-8), which are believed to be particularly destructive to tissue if present or generated in abnormal quantities or concentrations. Moreover, it has been discovered that many of these novel sulfur-nitrogen bonded compounds are selective in the inhibition of MMP-13, MMP-8, and/or other MMPs associated with diseased conditions without excessive inhibition of those collagenases essential to normal bodily function such as tissue turnover and repair or other zinc proteases. More particularly, it

has been found that many of the substituted-aryl- or substituted-heteroaryl-sulfonamide hydroxamic acids of the invention are selective for MMP-13 or MMP-8 with limited or minimal effect on MMP-1.

Among its many embodiments, the present invention is directed to a matrix metalloproteinase inhibiting compound having the structure of Formula VII:



Formula VII

wherein:

W is independently selected from the group consisting of $-NR^5COR^6$, $-NR^5S(O)_zR^7$ where z is zero, 1, or 2, $-NR^5COOR^8$, $-NR^5CONR^8R^9$ and $-NR^{11}R^{12}$.

R^1 is a hydrocarbyl diyl moiety or a substituted hydrocarbyl diyl moiety. R^1 can be aromatic, for example 1,2-phenylene, 1,3-phenylene, 1,4-phenylene, naphthalene-1,4-diyl, or naphthalene-1,5-diyl. Alternatively, R^1 can be aliphatic, for example methylene, ethane-1,2-diyl, propane-1,2-diyl, or propane-1,3-diyl. R^1 can be a straight-chain hydrocarbyl diyl moiety, or it can be branched. For example, R^1 can be 2-methylpropane-1,3-diyl. Furthermore, R^1 can contain one or more unsaturations. For example, R^1 can be prop-1-ene-1,3-diyl or a cycloalkylene such as anti-1,4-cyclohexane diyl. R^1 can also contain a heteroatom (e.g., O, N, or S). For example, R^1 can be a heteroarylene such as pyridine-2,5-diyl or R^1 can be an aliphatic heterocycle such as morpholine-1,3-diyl. Where R^1 contains a heteroatom,

the point of attachment of R^1 to the molecule can be at a heteroatom of R^1 or it can be at a carbon atom of R^1.

R^2 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, heterocycloalkylalkyl aralkyl, heteroarylalkyl, cycloalkylalkyl, heterocycloalkylalkyl, alkoxyalkyl, alkylthioalkyl, hydroxycarbonylalkyl, alkylcycloalkyl, heterocycloalkylalkyl, aroylalkyl, and heteroaroylalkyl group, $-(CH_2)_x-NR^{11}R^{12}$, or $-(CH_2)_x-C(O)NR^{11}R^{12}$, wherein x is an integer from zero to 6.

R^3 and R^4 are independently selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, and heterocycloalkyl, aryl, aralkyl, thioalkyl, heteroaralkyl, heteroaryl, alkoxyalkoxyalkyl, trifluoromethylalkyl, alkoxycarbonylalkyl, aralkoxycarbonylalkyl, hydroxycarbonylalkyl, alkoxyalkyl, heterocycloalkylalkyl, aryloxyalkyl, alkylthioalkyl, arylthioalkyl, heteroarylthioalkyl group, or a sulfoxide or sulfone of any of said thio-containing groups, a $-(CH_2)_x-C(O)NR^{11}R^{12}$ group, wherein x is an integer from zero to 6, and a $-(CH_2)_y-W$ group, wherein y is an integer from 1 to 6 and W is defined above. Preferably, R^4 is H or a C_1 to about C_{12} alkyl group. More preferably, R^4 is H or a C_1 to about C_4 alkyl group. Still more preferably R^4 is H.

R^2 and R^3 together with the atom chain to which they are attached can optionally form a ring comprising about 3 to about 8 members.

R^4 is selected from the group consisting of H and C_1 to about C_{20} alkyl group.

R^5 is selected from the group consisting of H and C_1 to about C_{20} alkyl group.

R^6 is selected from the group consisting of H, cycloalkyl, heterocycloalkyl, aryl, heteroaryl, arylalkyl, alkylaryl, heteroaralkyl, cycloalkylalkyl, heterocycloalkylalkyl, alkoxyalkyl, alkylthioalkyl group, and a $-(CH_2)_x-NR^{11}R^{12}$ group wherein x is an integer from zero to about 6. The aryl or heteroaryl groups of R^6 are optionally substituted (unsubstituted or substituted) with one or more substituents independently selected from the group consisting of a halogen, C_1 to about C_{20} alkyl, C_1 to about C_{20} alkenyl, C_1 to about C_{20} alkynyl, C_1 to about C_{20} alkoxy, nitro, cyano, hydroxy, carboxy, hydroxycarbonylalkyl, $-(CH_2)_x-NR^{11}R^{12}$, wherein x is an number from zero to about 6, trifluoromethyl, alkoxycarbonyl, aminocarbonyl, thio, alkylsulfonyl, carbonylamino, aminosulfonyl, alkylsulfonamino, alkoxyalkyl, cycolalkyloxy, alkylthioalkyl or alkylthio.

Optionally, R^5 and R^6 together with the atom chain to which they are bonded can form an about 5- to about 7-membered a cyclic amide or imide that is substituted or unsubstituted.

Also optionally, R^5 and R^7 together with the atom chain to which they are bonded can form an about 5- to about 7-membered a cyclic sulfonamide that is substituted or unsubstituted.

R^7 is selected from the group consisting of R^6 and alkyl;

R^8 and R^9 are independently selected from the group consisting of R^6 and alkyl, or R^8 and R^9 together with the nitrogen atom to which they are attached form an about 5- to about 7-membered ring containing zero or one heteroatom that is oxygen, nitrogen or sulfur;

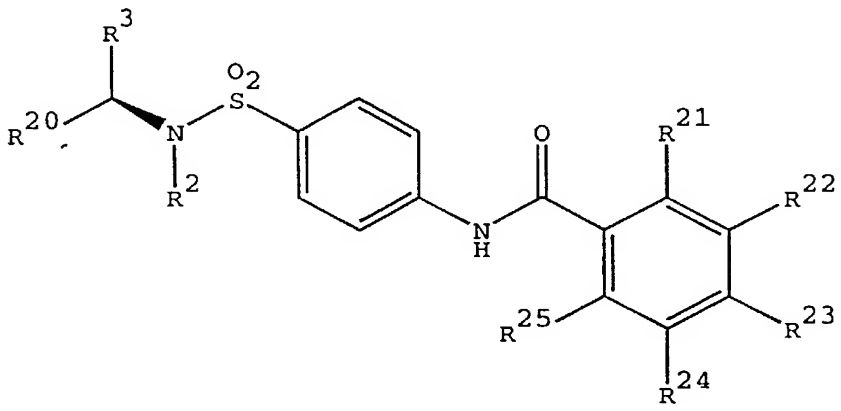
R^{11} and R^{12} are independently selected from the group consisting of H, alkyl, aryl, aralkyl, heteroaryl, heteroaralkyl, cycloalkyl, alkanoyl, aralkanoyl, and heteroaralkanoyl group, or R^{11} and R^{12} taken together

form an about 5- to about 8-membered heterocyclo or heteroaryl ring; and

R^{13} is selected from the group consisting of H or C_1 to about C_6 alkyl group.

R^{20} is selected from the group consisting of -C(O)OH, -C(O)NHOH, -SH, and -C(O)SH.

Preferably, the compound of the present invention has a structure of Formula VIII:



Formula VIII

or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof, wherein:

R^2 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, and heterocycloalkylalkyl;

R^3 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, haloalkoxy, haloalkylthio, and heterocycloalkyl;

R^{20} is selected from the group consisting of -C(O)OH, -C(O)NHOH, -SH, and -C(O)SH; and

R^{21}, R^{22}, R^{23}, R^{24}, and R^{25} are independently selected from the group consisting of H, C_1 to about C_{20} alkyl, C_1 to about C_{20} alkenyl, C_1 to about C_{20} alkynyl, cycloalkyl, haloalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, nitroalkyl, heterocycloalkyl, alkoxy, cycloalkoxy, alkoxycarbonyl, alkoxyalkyl, haloalkoxy, haloalkylthio, alkylamino, and carboxyalkyl.

Also, R^2 can be selected from the group consisting of any of the N-bonded substituent groups of the following bases: 4-acetyl cytidine; 5-(carboxyhydroxylmethyl)uridine; 2'-O-methylpséudouridine; beta,D-galactosylquiosine; 2'-O-methylguanosine; inosine; N6-isopentenyladenosine; 1-methyladenosine; 1-methylpseudouridine; 1-methylguanosine; 1-methylinosine; 2,2-dimethylguanosine; 2-methyladenosine; 2-methylguanosine; 3-methylcytidine; 5-methylcytidine; N6-methyladenosine; 7-methylguanosine; 5-methoxyaminomethyl-2-thiouridine; beta, D-mannosylqueosine; 5-methoxycarbonylmethyluridine; 5-methoxyuridine; 2-methylthio-N6-isopentenyladenosine; N-((9-beta-D-ribofuranosyl-2-methylthiopurine-6-yl)carbamoyl)threonine; N-((9-beta-D-ribofuranolylpurine-6-yl)N-methyl-carbamoyl)threonine; uridine-5-oxyacetic methyl ester; uridine-5-oxyacetic acid (v); wybutoxosine; pseudouridine; queosine; 2-thiocytidine; 5-methyl-2-thiouridine; 2-thiouridine; 4-thiouridine; 5-methyluridine; N-((9-beta-D-ribofuranosylpurine-6-yl)carbamoyl)threonine; 2'-O-methyl-5-methyluridine; 2'-O-methyluridine; wybutosine; and 3-(3-amino-3-carboxypropyl)uridine, (acp3)u.

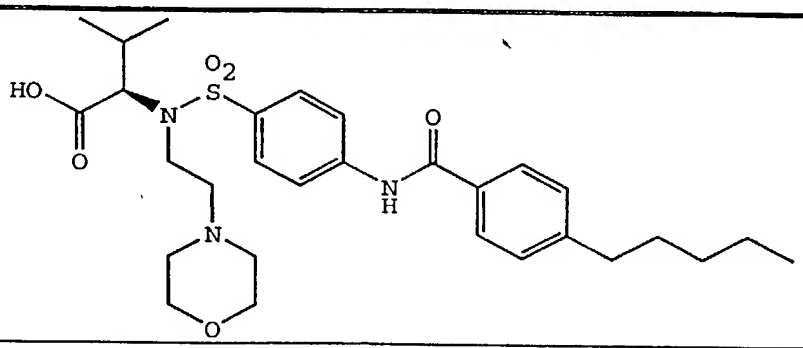
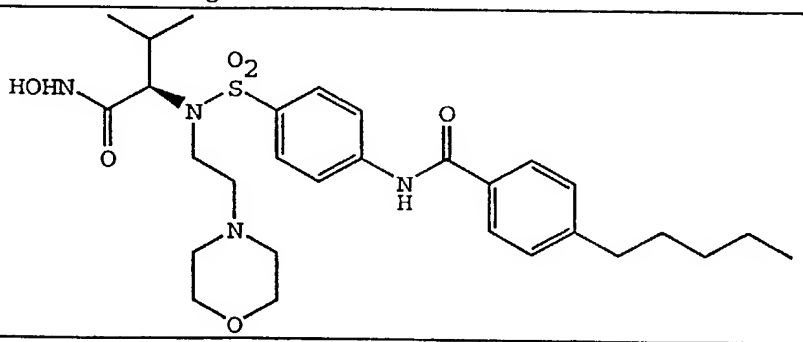
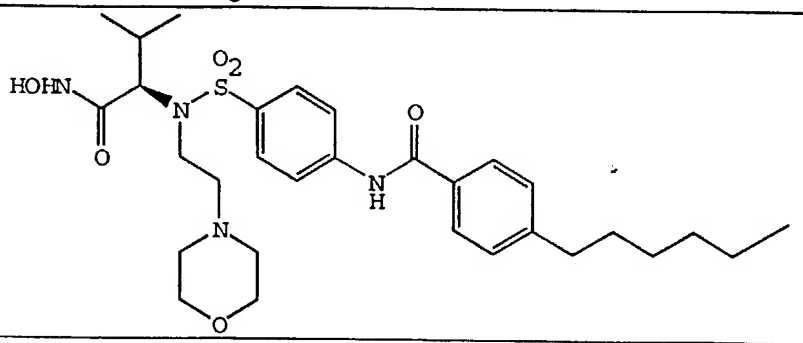
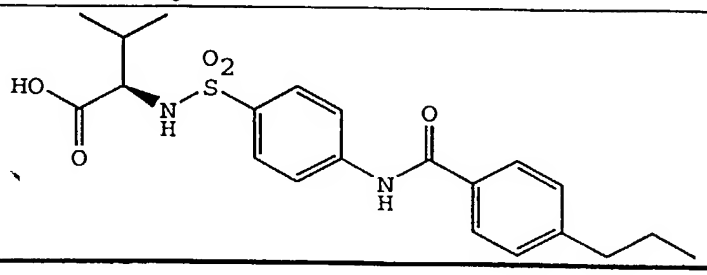
Further, R^2 can be selected from the group consisting of any of the side chains of the following amino acids: 2-aminoadipic acid; 3-aminoadipic acid; beta-alanine, beta-aminopropionic acid; 2-aminobutyric

acid; 4-aminobutyric acid, piperidinic acid; 6-aminocaproic acid; 2-aminoheptanoic acid; 2-aminoisobutyric acid; 3-aminopimelic acid; 2,4-diaminobutyric acid; desmosine; 2,2'-diaminpimelic acid; 2,3-diaminopripionic acid; N-ethylglycine; N-ethylasparagine; hydroxylysine; allo-hydroxylysine; isodesmosine; allo-isoleucine; N-methylglycine, sarcosine; N-methylisoleucine; N-methylvaline; norvaline; norleucine; and ornithine.

Preferably, R^{20} of Formula VIII is selected from the group consisting of -C(O)OH and -C(O)NHOH. Preferably R^{21} and R^{25} of Formula VIII are both H. More preferably, R^{21}, R^{22}, R^{24}, and R^{25} are H. When R^{21}, R^{22}, R^{24}, and R^{25} are H, preferably R^{23} is C_1 to about C_{20} alkyl and more preferably R^{23} is C_1 to about C_{20} linear alkyl. When R^{20} of Formula VIII is -C(O)OH, R^3 is preferably selected from the group consisting of alkyl, alkenyl, alkynyl, haloalkoxy, haloalkylthio, and heterocycloalkyl; more preferably R^3 is heterocycloalkyl, and more preferably still R^3 is 2-(N-morpholino)ethyl. When R^{20} of Formula VIII is -C(O)NHOH, R^3 is preferably selected from the group consisting of alkyl, alkenyl, alkynyl, haloalkoxy, haloalkylthio, and heterocycloalkyl; more preferably R^3 is heterocycloalkyl, and more preferably still R^3 is 2-(N-morpholino)ethyl.

Table I below shows preferred compounds of the present invention. The represented compounds are meant to include their salts, enantiomers, diastereomers, racemates, and tautomers.

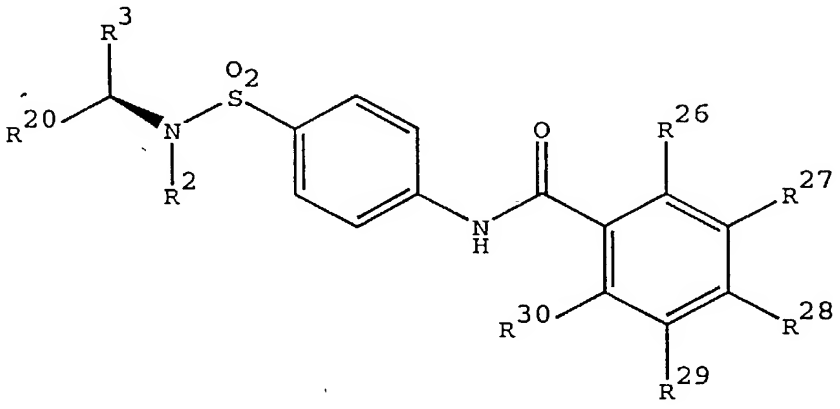
Table I.

Formula Number	Structure
IX	
X	
XI	
XII	

Without being bound to a particular mechanism, it is believed that some of the compounds of the present

invention provide selective inhibition of certain MMPs, particularly MMP-8 or MMP-13, in part by causing a change in the conformation of the amino acid residue backbone of the inhibited MMP.

The present invention is further directed to a method of changing the conformation of a matrix metalloproteinase wherein the method comprises contacting the matrix metalloproteinase with a compound having the structure of Formula XIII:



Formula XIII

or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof, thereby changing the conformation of the matrix metalloproteinase, wherein:

R^2 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, and heterocycloalkylalkyl;

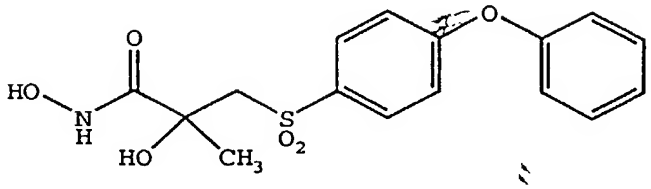
R^3 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, and heterocycloalkyl;

R^{20} is selected from the group consisting of -C(O)OH, -C(O)NHOH, -SH, and -C(O)SH; and

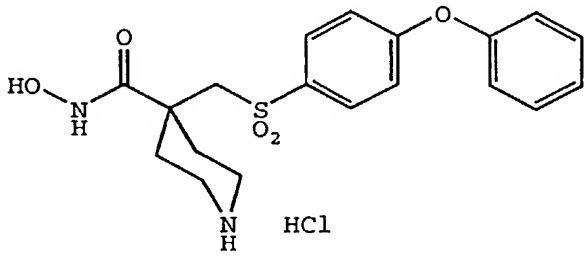
R^{26}, R^{27}, R^{28}, R^{29}, and R^{30} are independently selected from the group consisting of about C_3 to about C_{20} alkyl, about C_3 to about C_{20} alkenyl, about C_3 to about C_{20} alkynyl, cycloalkyl, haloalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, nitroalkyl, heterocycloalkyl, and carboxyalkyl.

Preferably for the method of changing the conformation of an MMP, R^{20} of Formula XIII is selected from the group consisting of -C(O)OH and -C(O)NHOH. R^3 is preferably a C_1 to about C_{12} alkyl, more preferably R^3 is a C_1 to about C_4 alkyl, and more preferably still R^3 is isopropyl. R^2 is preferably heterocycloalkylalkyl and more preferably R^2 is 2-(N-morpholino)ethyl. Preferably R^{26} and R^{30} are H. More preferably, R^{26}, R^{27}, R^{29}, and R^{30} are H. R^{28} can be an alkyl group of any convenient size. When R^{26}, R^{27}, R^{29}, and R^{30} are H, R^{28} is preferably about C_3 to about C_{20} alkyl and more preferably R^{28} is about C_3 to about C_{20} linear alkyl. More preferably still R^{28} is n-propyl, n-butyl, n-pentyl or n-hexyl. Compounds IX, X, XI, and XII of Table I (or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof) each is useful in the present invention.

Surprisingly, the compounds of the Formula XIII are particularly useful in changing the conformation of MMP enzymes, especially MMP-8 and/or MMP-13. Crystal structures of MMP-8 complexed with MMP inhibitor compounds of Formula XIII compared with crystal structures of MMP-8 complexed with the compound of Formula XIV or the compound of Formula XV establish a three-dimensional structure-activity relationship.



Formula XIV



Formula XV

The catalytic domain (residues 85-242) of MMP-8, neutrophil collagenase, folds into a compact globular structure. It has an approximate diameter of 30 Å. The inhibitors interact with the protein through chelation of the catalytic zinc ion, hydrogen bonding with the backbone -NH- of Leu 160, and hydrophobic interactions in the nonpolar S1' pocket. In MMP-8, the S1' pocket is formed from residues 193-197 that form a turn of a longer helix and residues 214-229 of a loop region. The S1' pocket in MMP-8 is not as deep as in some other MMPs (e.g., stromelysin). The accompanying figures show the effect on the conformation of the S1' pocket as the P1' substituent on the inhibitor is made progressively longer.

Figure 2 shows the structures of inhibitor molecules of Formulae XII, IX, X, and XI superimposed upon one another, wherein the structures were determined by the X-ray crystallographic techniques described herein. The Figure shows the co-extensive reach of the

P1' arms of the inhibitors, except that as the alkyl group of the 4-alkylbenzamide moiety increases in length, the steric requirements of each inhibitor also increases. The P1' arm of each inhibitor fits into the MMP-8 S1' pocket. In order to accommodate an increase in the steric requirement of the P1' arm, the amino acid residues of the S1' pocket must change their conformations.

Figure 3 shows MMP-8 S1' amino acid backbone residues which reside within 5 Å of a complexed inhibitor molecule as determined by the X-ray crystallographic techniques described herein. A blank in Figure 3 indicates that the residue lies within 5 Å of the inhibitor whereas the word "no" indicates that the residue lies further than 5 Å from the complexed inhibitor.

Figure 4 shows a comparison of the S1' pockets of MMP-1 and of MMP-8.

Figures 5, 6, 7, and 8 show the effect of progressively lengthening the P1' group of the MMP inhibitor on the conformation of the substituents on amino acid residues of the S1' pocket.

Figure 5 shows a comparison of the X-ray crystallographic conformation of amino acid residues in the S1' pocket of MMP-8 when either the compound of Formula XII (colored) or the compound of Formula XIV (grey) is complexed with MMP-8. The figure shows that the P1' group (including the 4-propylbenzamide moiety) of XII sterically interferes with the side chain of the Arg 222 (R222) residue of the S1' pocket while the P1' group of XIV is much shorter and does not sterically interfere with the Arg 222 the side chain. Complexed XII causes the Arg 222 the side chain to move out of the way of the large P1' group of XII.

Figure 6 shows a comparison of the X-ray crystallographic conformation of amino acid residues in

the S1' pocket of MMP-8 when either the compound of Formula XII (colored) or the compound of Formula IX (grey) is complexed with MMP-8. The P1' group of IX (including the 4-pentylbenzamide moiety) is larger still than the P1' group of XII. Because of increased steric interference, the IX P1' group causes the the side chain of the Arg 222 (R222) residue of the S1' pocket to move even further away from the pocket than does the P1' group of XII.

Figure 7 shows a comparison of the X-ray crystallographic conformation of amino acid residues in the S1' pocket of MMP-8 when either the compound of Formula XII (colored) or the compound of Formula X (grey) is complexed with MMP-8. The P1' group of X (including the 4-hexylbenzamide moiety) is larger still than the P1' group of XII. Because of increased steric interference, the P1' group of X causes the side chain of the Arg 222 (R222) residue of the S1' pocket to move as far or further away from the pocket than does the XII P1' group.

Figure 8 shows a comparison of the X-ray crystallographic conformation of amino acid residues in the S1' pocket of MMP-8 when either the compound of Formula XII (colored) or the compound of Formula XI (grey) is complexed with MMP-8. This Figure shows a result similar to that of Figure 7.

Figures 9, 10, 11, and 12 show the effect of progressively lengthening the P1' group of the MMP inhibitor on the conformation of the backbone of the S1' pocket.

Figure 9 shows a comparison of the X-ray crystallographic conformation of the amino acid backbone of the S1' pocket of MMP-8 when either the compound of Formula XII (green) or the compound of Formula XIV (red) is complexed with MMP-8. Although Figure 9 demonstrates that XII affects the conformation of the side chain of

the Arg 222 (R222) residue of the S1' pocket relative to XIV, Figure 9 also shows that each compound has essentially no effect on the conformation of the amino acid backbone (shown as a ribbon in Figure 9). Tyr 227 (Y227) shows little change when either XII or XIV is complexed in the S1' pocket.

Figure 10 shows a comparison of the X-ray crystallographic conformation of the amino acid backbone of the S1' pocket of MMP-8 when either the compound of Formula XII (red) or the compound of Formula X (yellow) is complexed with MMP-8. The longer 4-pentylbenzamide moiety of X causes the backbone to deform significantly relative to the case in which XII is complexed. In addition, X causes the Arg 222 and Tyr 227 side chains to move significantly relative to the case in which XII is complexed.

Figure 11 shows a comparison of the X-ray crystallographic conformation of the amino acid backbone of the S1' pocket of MMP-8 when either the compound of Formula XII (red) or the compound of Formula IX (yellow) is complexed with MMP-8. The longer 4-pentylbenzamide moiety of IX causes the backbone to deform significantly relative to the case in which XII is complexed. In addition, IX causes the Arg 222 and Tyr 227 side chains to move significantly relative to the case in which XII is complexed.

Figure 12 shows a comparison of the X-ray crystallographic conformation of the amino acid backbone of the S1' pocket of MMP-8 when either the compound of Formula XII (red) or the compound of Formula XI (blue) is complexed with MMP-8. The longer 4-hexylbenzamide moiety of XI causes the backbone to deform significantly relative to the case in which XII is complexed. In addition, XI causes the Arg 222 and Tyr 227 side chains to move significantly relative to the case in which XII is complexed.

Figure 13 shows the temperature factor (B) distribution for MMP-8 complexes with inhibitor compounds XII (red), IX (orange), X (yellow), XI (blue), and XIV (white). Complexes with XII and XIV show similar temperature factors indicating that the MMP-8 backbone has similar thermal motion in both cases. However, XI, X, and IX complexes cause a progressive increase in the temperature factor in residues 221-230, indicating that they are causing greater thermal motion in that region of the S1' pocket of MMP-8 relative to compounds X or XIV.

Figure 14 shows the (ϕ,ψ) distribution among the amino acid residues of MMP-8 from 222 to 231.

Figure 15 shows an electrostatic surface of one aspect of the overall MMP-8 enzyme in which the inhibitor compound of Formula XIV has been complexed. Figure 16 shows an electrostatic surface of one aspect of the overall MMP-8 enzyme in which the inhibitor compound of Formula XI has been complexed. Figure 16 (center) shows that the XI has caused a change in the conformation of MMP-8 relative to XIV as evidenced by the opening created by XI in the S1' pocket caused by the change in conformation of the amino acid residue backbone of MMP-8. This opening is absent from the XIV-MMP-8 complex shown in Figure 15. The electrostatic surfaces were calculated and drawing using the GRASP program (A. Nicholls et al., "Protein folding and association: Insights from the interfacial and thermodynamic properties of hydrocarbons," *Protein Str. Funct. Gen.* 11, 281-296 (1991)).

These figures demonstrate that stepwise changes of the MMP-8 protein are observed in progressing from complexes of MMP-8 with XIV, XII, IX, X, and XI. The S1' pocket becomes deeper, first by the movement of amino acid residue side chains (especially Arg 222 and

Tyr 227), then by a movement of the backbone in the 224-228 region.

The present invention is also directed to a method of inhibiting a matrix metalloproteinase wherein the method comprises contacting the matrix metalloproteinase with a compound of Formula VIII (for which each of the substituents are as defined above) thereby inhibiting the matrix metalloproteinase. Preferably for the method of inhibiting an MMP, R^{20} of Formula XIII is selected from the group consisting of -C(O)OH and -C(O)NHOH. R^3 is preferably a C_1 to about C_{12} alkyl, more preferably R^3 is a C_1 to about C_4 alkyl, and more preferably still R^3 is isopropyl. R^2 is preferably heterocycloalkylalkyl and more preferably R^2 is 2-(N-morpholino)ethyl. Preferably R^{21} and R^{25} of Formula VIII are both H. More preferably, R^{21}, R^{22}, R^{24}, and R^{25} are H. R^{23} can be an alkyl group of any convenient size. When R^{21}, R^{22}, R^{24}, and R^{25} are H, preferably R^{23} is C_1 to about C_{20} alkyl and more preferably R^{23} is C_1 to about C_{20} linear alkyl. Compounds IX, X, XI, and XII of Table I (or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof) each is useful in the present invention. The compounds of the present invention are particularly useful in inhibiting MMP-8 and/or MMP-13.

Another embodiment of the present invention is directed toward a method for the treatment of osteoarthritis in a mammal wherein the method comprises providing to the mammal an osteoarthritis-treating-effective amount of a compound of Formula VIII (for which each of the substituents are as defined above). The mammal can be, for example, a human. Each of the compounds shown in Table I will be useful in the treatment of a human for osteoarthritis. Alternatively, the method for treating osteoarthritis can be directed to a veterinary subject, for example a cat or a dog.

c. Compound Syntheses

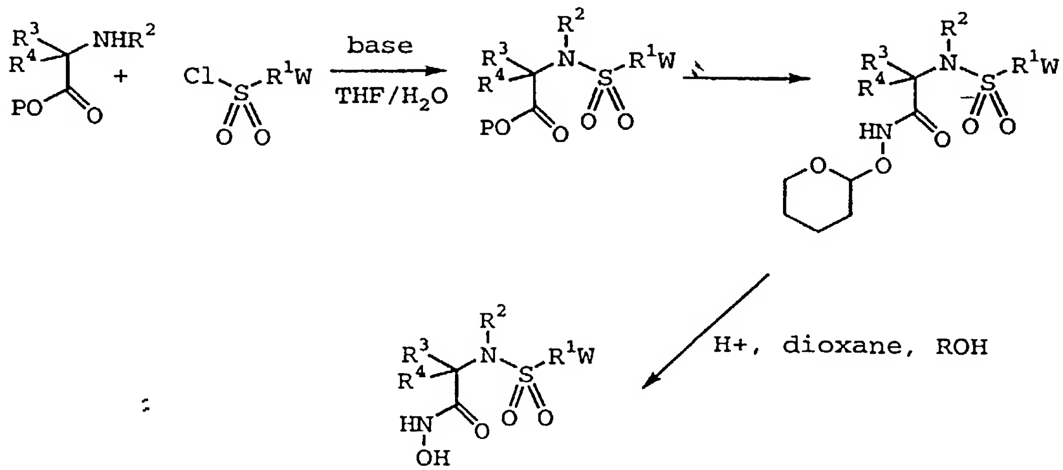
The starting materials for use in the preparation of the compounds of the present invention are known or can be prepared by conventional methods known to a skilled person or in an analogous manner to processes described in the art.

Generally, the compounds of the present invention can be prepared by methods described in detail in U.S. Patent Application No. 09/230,205, herein incorporated by reference.

Schemes I and III and Schemes 1, 2, 4, 5, 6, and 7 illustrate procedures with examples of chemical transformations that may be useful for the preparation of compounds of this invention. These syntheses, as with all of the reactions discussed herein, can be carried out under a dry inert atmosphere such a nitrogen or argon if desired. Selected reactions known to those skilled in the art, can be carried out under a dry atmosphere such as dry air whereas other synthetic steps, for example, aqueous acid or base ester or amide hydrolyses, can be carried out under laboratory air.

Thus, in general, the choices of starting material and reaction conditions can vary as is well know to those skilled in the art. Usually, no single set of conditions is limiting since variations can be applied as required. Conditions will also will be selected as desired to suit a specific purpose such as small scale preparations or large scale preparations. In either case, the use of less safe or less environmentally sound materials or reagents will usually be minimized. Examples of such less desirable materials are diazomethane, diethyl ether, heavy metal salts, dimethyl sulfide, chloroform, benzene and the like.

Scheme 1



Formula I

P = H, protecting group

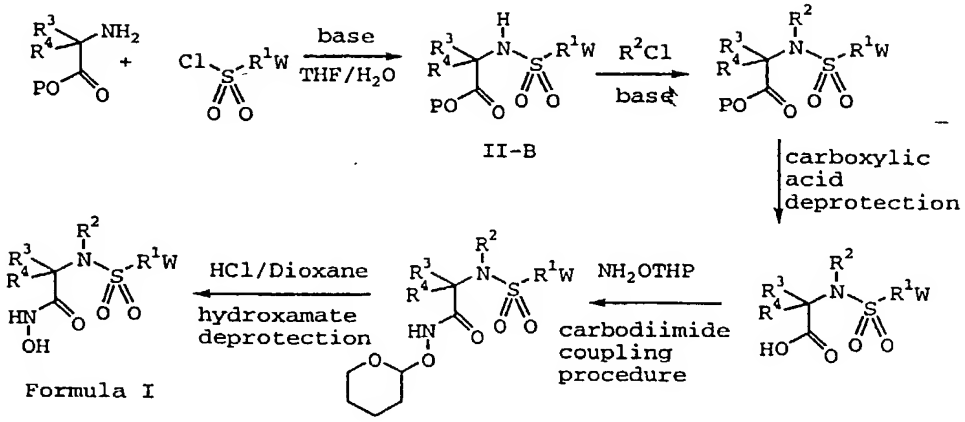
Scheme 1 shows the conversion of an N-substituted alpha-amino acid, protected or unprotected, into a compound of Formula I. The amino acid may be protected with a group P such as an alkyl ester such as methyl, ethyl, tert-butyl, tetrahydropyranyl and the like or arylalkyl ester such as benzyl. Treatment of this amine with a sulfonyl, sulfinyl or sulfenyl chloride would provide the corresponding amide. A base would normally be used to inactivate the HCl released from the acid chloride and it would be such that it would not react with the sulfonyl chloride, i.e., ammonia, primary or secondary amines would not normally be used. Examples of bases that can be used include, for example, metal hydroxides such as sodium, potassium, lithium or magnesium hydroxide, oxides such as those of sodium, potassium, lithium, calcium or magnesium, metal carbonates such as those of sodium, potassium, lithium, calcium or magnesium, metal bicarbonates such as sodium

bicarbonate or potassium bicarbonate, primary, secondary or tertiary organic amines such as alkyl amines, arylalkyl amines, alkylarylalkyl amines, heterocyclic amines or heteroaryl amines, ammonium hydroxides or quaternary ammonium hydroxides. As non-limiting examples, such amines can include triethyl amine, trimethyl amine, diisopropyl amine, methyldiisopropyl amine, diazabicyclononane, tribenzyl amine, dimethylbenzyl amine, morpholine, N-methylmorpholine, N,N'-dimethylpiperazine, N-ethylpiperidine, 1,1,5,5-tetramethylpiperidine, dimethylaminopyridine, pyridine, quinoline, tetramethylethylenediamine and the like. Non-limiting examples of ammonium hydroxides, usually made from amines and water, can include ammonium hydroxide, triethyl ammonium hydroxide, trimethyl ammonium hydroxide, methyldiiospropyl ammonium hydroxide, tribenzyl ammonium hydroxide, dimethylbenzyl ammonium hydroxide, morpholinium hydroxide, N-methylmorpholinium hydroxide, N,N'-dimethylpiperazinium hydroxide, N-ethylpiperidinium hydroxide, and the like. As non-limiting examples, quaternary ammonium hydroxides can include tetraethyl ammonium hydroxide, tetramethyl ammonium hydroxide, dimethyldiiospropyl ammonium hydroxide, benzymethyldiisopropyl ammonium hydroxide, methyldiazabicyclononyl ammonium hydroxide, methyltribenzyl ammonium hydroxide, N,N-dimethylmorpholinium hydroxide, N,N,N',N'-tetramethylpiperazenium hydroxide, and N-ethyl-N'-hexylpiperidinium hydroxide and the like. Metal hydrides, amide or alcoholates such as calcium hydride, sodium hydride, potassium hydride, lithium hydride, sodium methoxide, potassium tert-butoxide, calcium ethoxide, magnesium ethoxide, sodium amide, potassium diisopropyl amide and the like may also be suitable reagents. Organometallic deprotonating agents such as alkyl or aryl lithium reagents such as methyl, phenyl or

butyl lithium, Grignard reagents such as methylmagnesium bromide or methylmagnesium chloride, organocadmium reagents such as dimethylcadmium and the like may also serve as bases for causing salt formation or catalyzing the reaction. Quaternary ammonium hydroxides or mixed salts are also useful for aiding phase transfer couplings or serving as phase transfer reagents.

The first reaction in Scheme 1 also illustrated the use of a mixed solvent THF/H_2O. This is one solvent system however others may be useful also. For example, the reaction media can consist of a single solvent, mixed solvents of the same or different classes or serve as a reagent in a single or mixed solvent system. The solvents can be protic, non-protic or dipolar aprotic. Non-limiting examples of protic solvents include water, methanol (MeOH), denatured or pure 95% or absolute ethanol, isopropanol and the like. Typical non-protic solvents include acetone, tetrahydrofuran (THF), dioxane, diethylether (ether), tert-butylmethyl ether (TBME), aromatics such as xylene, toluene, or benzene, ethyl acetate, methyl acetate, butyl acetate, trichloroethane, methylene chloride, ethylenedichloride (EDC), hexane, heptane, isooctane, cyclohexane and the like. Dipolar aprotic solvents include compounds such as dimethylformamide (DMF), dimethylacetamide (DMAc), acetonitrile, nitromethane, tetramethylurea, N-methylpyrrolidone and the like.

Scheme 2



P = H, protecting group

Non-limiting examples of ammonium hydroxides, usually made from amines and water, can include ammonium hydroxide, triethyl ammonium hydroxide, trimethyl ammonium hydroxide, methyldiiospropyl ammonium hydroxide, tribenzyl ammonium hydroxide, dimethylbenzyl ammonium hydroxide, morpholinium hydroxide, N-methylmorpholinium hydroxide, N,N'dimethylpiperazinium hydroxide, N-ethylpiperidinium hydroxide, and the like. As non-limiting examples, quaternary ammonium hydroxides can include tetraethyl ammonium hydroxide, tetramethyl ammonium hydroxide, dimethyldiiospropyl ammonium hydroxide, benzymethyldiisopropyl ammonium hydroxide, methyldiazabicyclononyl ammonium hydroxide, methyltribenzyl ammonium hydroxide, N,N-dimethylmorpholinium hydroxide, N,N,N',N'-tetramethylpiperazenium hydroxide, and N-ethyl-N'-hexylpiperidinium hydroxide and the like. Metal hydrides, amide or alcoholates such as calcium hydride, sodium hydride, potassium hydride, lithium hydride, sodium methoxide, potassium tert-butoxide, calcium

ethoxide, magnesium ethoxide, sodium amide, potassium diisopropyl amide and the like may also be suitable reagents. Organometallic deprotonating agents such as alkyl or aryl lithium reagents such as methyl, phenyl or butyl lithium, Grignard reagents such as methylmagnesium bromide or methylmagnesium chloride, organocadmium reagents such as dimethylcadmium and the like may also serve as bases for causing salt formation or catalyzing the reaction. Quaternary ammonium hydroxides or mixed salts are also useful for aiding phase transfer couplings or serving as phase transfer reagents.

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Non-limiting examples of reagents that can be used as solvents or as part of a mixed solvent system include organic or inorganic mono- or multi-protic acids or bases such as hydrochloric acid, phosphoric acid, sulfuric acid, acetic acid, formic acid, citric acid,

succinic acid, triethylamine, morpholine, N-methylmorpholine, piperidine, pyrazine, piperazine, pyridine, potassium hydroxide, sodium hydroxide, alcohols, ammonia or amines for making esters or amides and the like.

Acids are used in many reactions during various synthesis. Scheme 1 illustrates acid use for the removal of the THP protecting group to produce the hydroxamic acid of Formula I. The acid might be mono-, di- or tri-protic organic or inorganic acids. Examples of acids include hydrochloric acid, phosphoric acid, sulfuric acid, acetic acid, formic acid, citric acid, succinic acid, hydrobromic acid, hydrofluoric acid, carbonic acid, phosphorus acid, p-toluene sulfonic acid, trifluoromethane sulfonic acid, trifluoroacetic acid, difluoroacetic acid, benzoic acid, methane sulfonic acid, benzene sulfonic acid, 2,6-dimethylbenzene sulfonic acid, trichloroacetic acid, nitrobenzoic acid, dinitrobenzoic acid, trinitrobenzoic acid, and the like. They might also be Lewis acids such as aluminum chloride, borontrifluoride, antimony pentafluoride and the like. A preferred solvent in this type reaction is dioxane eith an alcohol or water however almost any solvent system with one component being a protic solvent can be useful.

Scheme I illustrates conversion of a carboxylic acid protected as an ester or amide into an hydroxamic acid derivative such as a O-arylalkylether or O-cycloalkoxyalkylether group. In particular, the this Scheme the protecting group on the hydroxylamine is the THP group. In the case where hydroxylamine is used, treatment of an ester or amide with one or more equivalents of hydroxylamine hydrochloride at room temperature or above in a solvent or solvents, usually protic or partially protic, such as those listed above can provide a hydroxamic acid directly. This exchange

process may be further catalyzed by the addition of additional acid. Alternatively, a base such as a salt of an alcohol used as a solvent, for example, sodium methoxide in methanol, can be used to form hydroxylamine from hydroxylamine hydrochloride in situ which can exchange with an ester or amide. As mentioned above, exchange can be carried out with a protected hydroxyl amine such as tetrahydropyranyl-hydroxyamine ($THPONH_2$), benzylhydroxylamine ($BnONH_2$), and the like in which case compounds such as shown in Scheme 1 that are tetrahydropyranyl (THP) or benzyl (Bn) hydroxamic acid derivatives are the products. Removal of the protecting groups when desired, for example, following further transformations in another part of the molecule or following storage, is accomplished by standard methods well known in the art such as acid hydrolysis of the THP group as discussed above or reductive removal of the benzyl group with hydrogen and a metal catalyst such as palladium, platinum, palladium on carbon or nickel.

In the case where P is hydrogen, i.e., where the intermediate is a carboxylic acid, standard coupling reactions can be used. For example, the acid can be converted into an acid chloride, mixed anhydride or activated ester and treated with hydroxylamine or a protected hydroxylamine in the presence of a non-competitive base to the nitrogen acylated compound. This is the same product as discussed above. Couplings of this nature are well known in the art and especially the art related to peptide and amino acid chemistry.

Scheme II illustrates another possible synthesis of the compounds of Formula I starting with a protected or unprotected amino acid. Sulfonylation of the amino group is accomplished as discussed above to produce the sulfonamide II-B. This compound is a secondary sulfonamide and, as such, is acidic and can be alkylated with an R^2 group. Alkylation, a process well known in

the art, can be carried by treatment of the sulfonamide with base to form the corresponding anion, adding an electrophilic reagent and allowing the SN_2 reaction to proceed. Electrophiles include halogen derivatives, sulfonate esters, epoxides and the like. The bases and solvents discussed with regard to Scheme I are applicable in this Scheme. Preferred bases are those that are hindered such that competition with the electrophile is minimized. Additional preferred bases are metal hydrides, amide anions or organometallic bases such as a butyl lithium. The solvents, solvent mixtures or solvent/reagent mixtures discussed are satisfactory but non-protic or dipolar aprotic solvents such as acetone, acetonitrile, DMF and the like are examples of preferred classes.

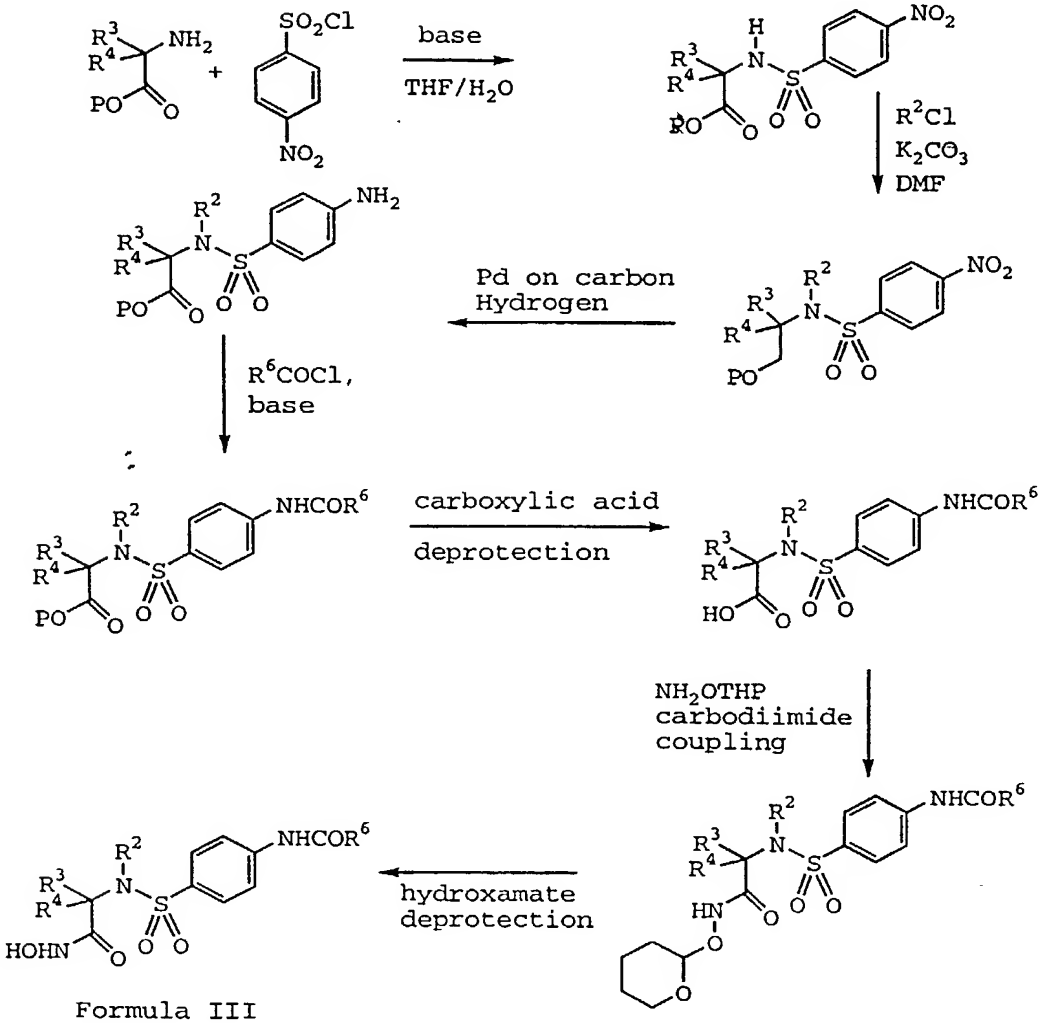
Scheme III illustrates the potential for use of a sulfonyl chloride reagent, specifically nitrobenzenesulfonyl chloride, to prepare compounds of this invention. It should be noted that this reagent is for illustration and is not to be considered limiting or required. After coupling with an amino acid and alkylation of the coupling product if required, the nitrosulfonamide can be reduced to provide a useful amino compound. The amino group can be alkylated if desired. It can also be acylated with an aroyl chloride, heteroaryl or other R^6 amine carbonyl froming agent to form a $-C(=O)-$ or $-S(=O)_n-$ compound of this invention. The amino sulfonamide can also be reacted with a carbonic acid ester chloride as shown in Scheme IV, a sulfonyl chloride as shown in Scheme V or in Scheme VII or a carbamoyl chloride or isocyanate as shown in Scheme VI to produce the corresponding carbamate, sulfonamides, or ureas of this invention. Acylation of amines of this type are well known in the art and the reagents are also well known. Usually these reactions are carried out in aprotic solvents under an

inert or/and dry atmosphere at about 45°C to about -10°C. An equivalent of a non-competitive base is usually used with sulfonyl chloride, acid chloride or carbonyl chloride reagents. Following this acylation step, synthesis of the hydroxamic acid products of this invention can proceed as discussed above for Scheme I and Scheme II.

Schemes II through VI also illustrate the possible reduction of a nitrobenzenesulfonamide to produce an amino sulfonamide. The reduction of nitro groups to amines is will know in the art with a preferred method being hydrogenation. There is usually a metal catalyst such as Rh, Pd, Pt, Ni or the like with or without an additional support such as carbon, barium carbonate and the like. Solvents can be protic or non-protic pure solvents or mixed solvents as required. The reductions can be carried out at atmospheric pressure to a pressure of multiple atmospheres with atmospheric pressure to about 40 pounds per square inch (psi) preferred.

Other sulfonyl chloride reagents can also be used in the preparation of compounds of this invention as outline in the Schemes. Examples are fluoroaryl or fluoroheteroaryl sulfonyl chlorides, azidoaryl or azidoheteroaryl or amide, carbonate, carbamate or urea substituted aryl or heteroaryl sulfonyl chloride reagents. Azides, for example, can be reduced to an amino group using hydrogen with a metal catalyst or metal chelate catalyst or activated hydride transfer reagent. The fluoro substituted sulfonic acid or sulfonamide can be treated with a nucleophile such as ammonia or a primary amine, under pressure if desired, to provide an amino or substituted (R5) amino group that can then be reacted a reagent as outline in Scheme III and in Schemes 4-7 inclusive.

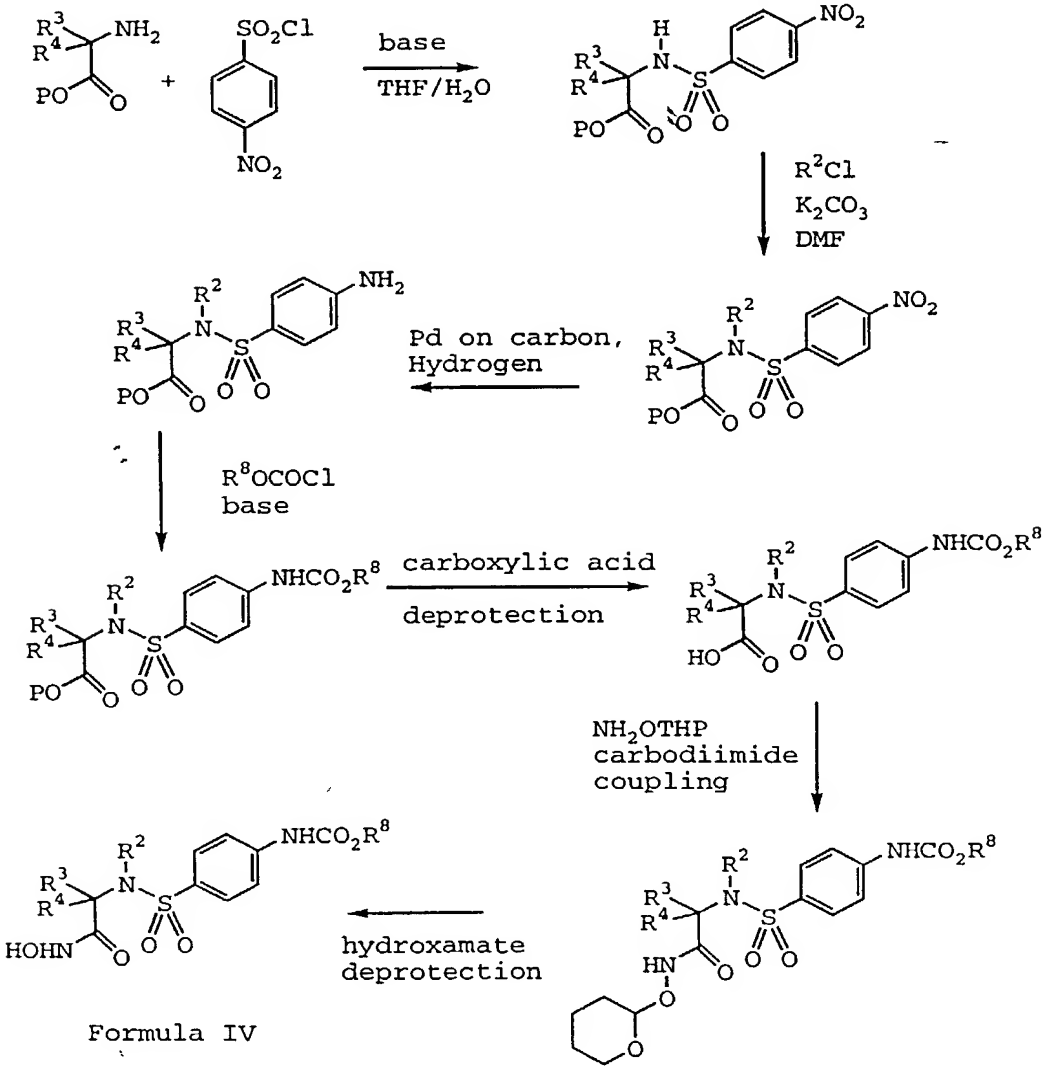
Scheme III



Formula III

P = H, protecting group

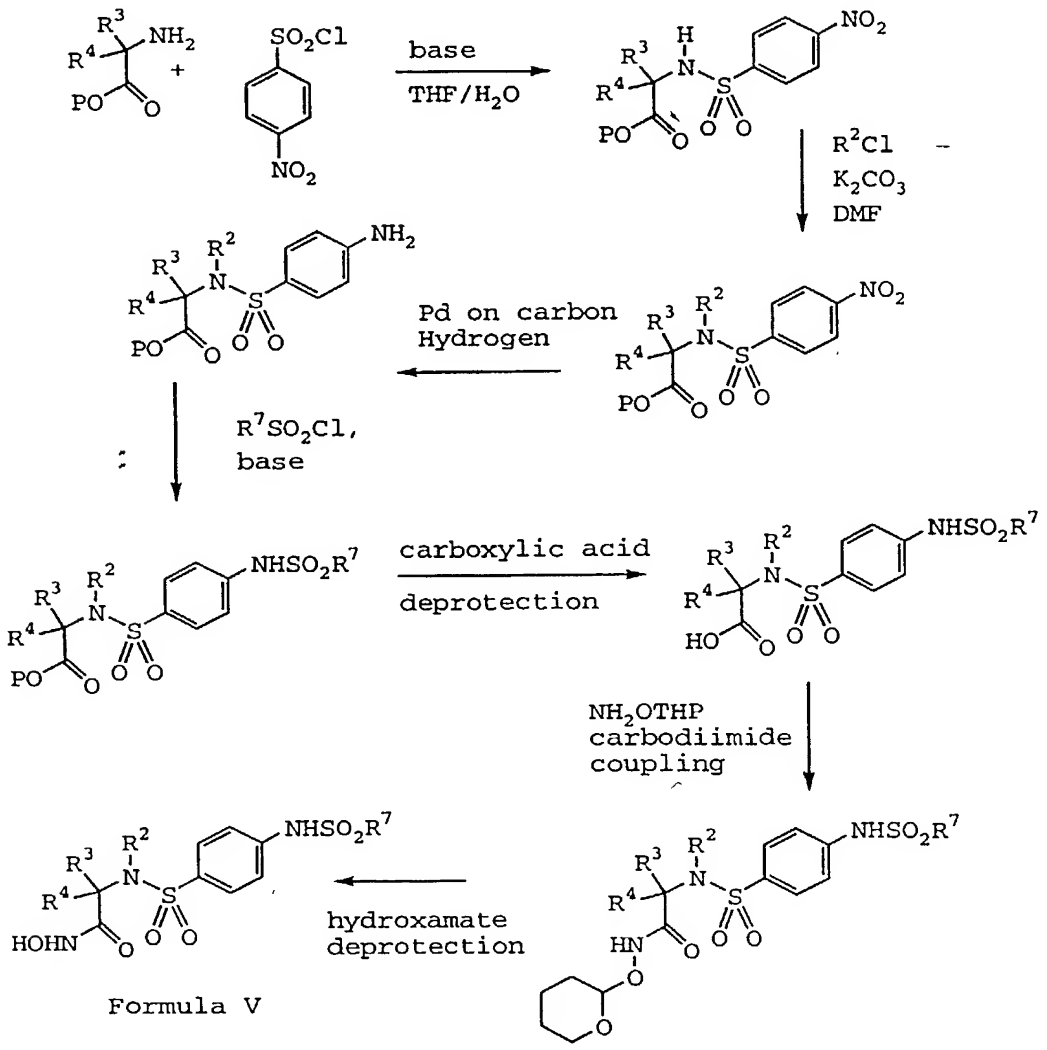
Scheme 4



Formula IV

P = H, protecting group

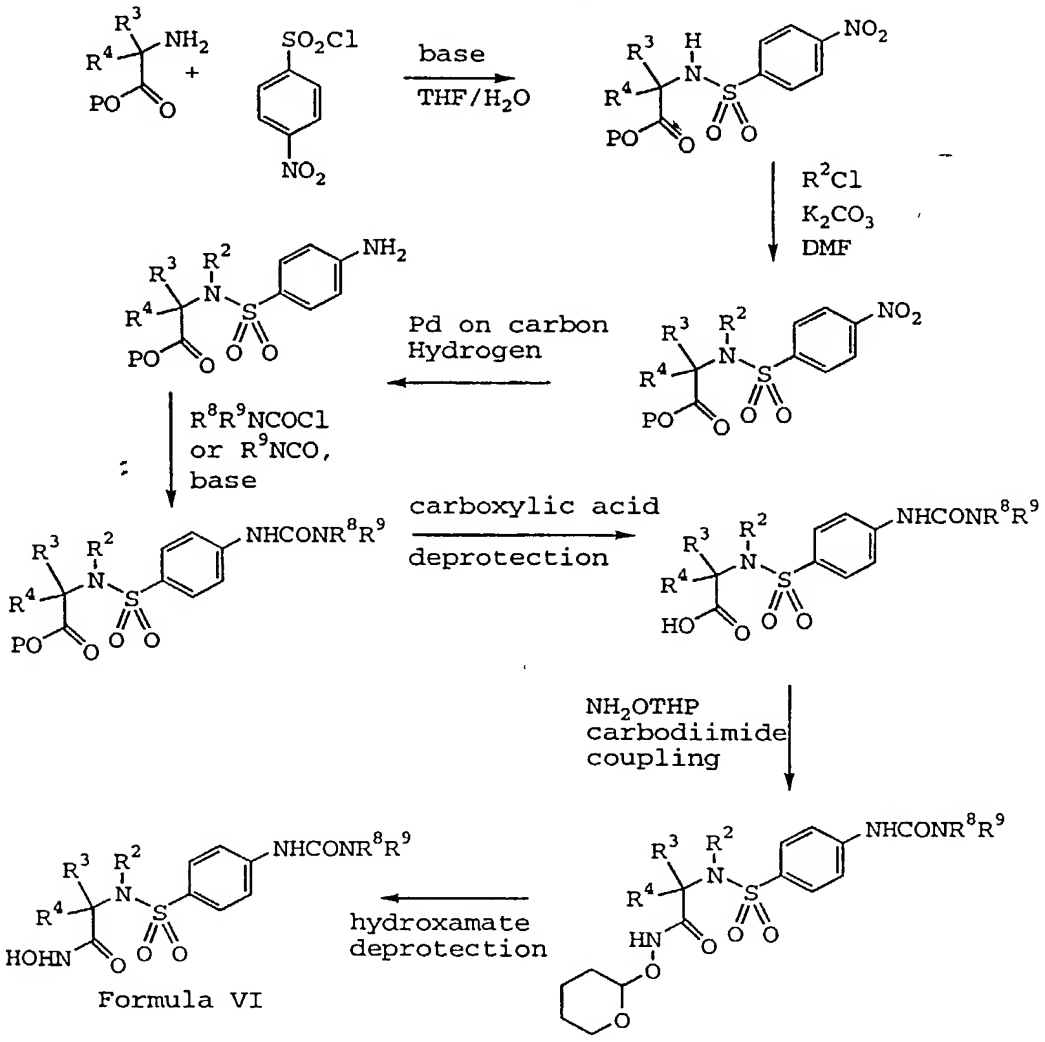
Scheme 5



Formula V

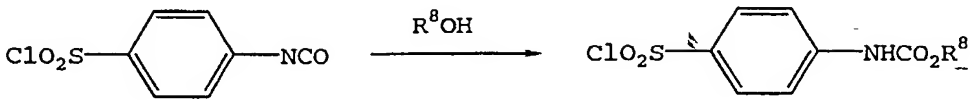
P = H, protecting Group

Scheme 6



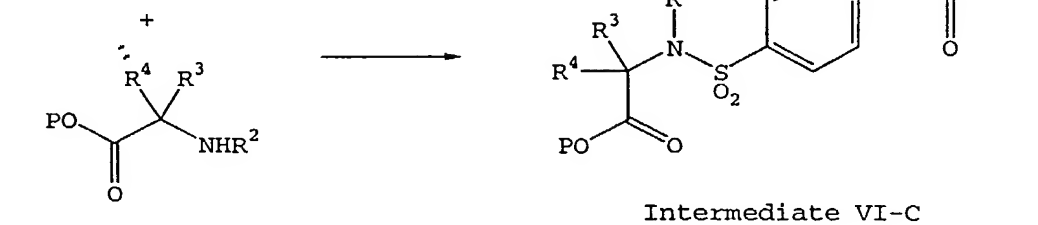
P = H, protecting group

Scheme 7



Intermediate IV-A

Intermediate IV-A



Intermediate VI-C

Compounds of the present can possess one or more asymmetric carbon atoms and are thus capable of existing in the form of optical isomers as well as in the form of racemic or nonracemic mixtures thereof. The optical isomers can be obtained by resolution of the racemic mixtures according to conventional processes well known in the art, for example by formation of diastereoisomeric salts by treatment with an optically active acid or base. Examples of appropriate acids are tartaric, diacetyltartaric, dibenzoyltartaric, ditoluoyltartaric and camphorsulfonic acid and then separation of the mixture of diastereoisomers by crystallization followed by liberation of the optically active bases from these salts. A different process for separation of optical isomers involves the use of a chiral chromatography column optimally chosen to maximize the separation of the enantiomers. Still another available method involves synthesis of covalent

diastereoisomeric molecules, e.g., esters, amides, acetals, ketals, and the like, by reacting compounds of Formula I with an optically active acid in an activated form, a optically active diol or an optically active isocyanate. The synthesized diastereoisomers can be separated by conventional means such as chromatography, distillation, crystallization or sublimation, and then hydrolyzed to deliver the enantiomericaly pure compound. In some cases hydrolysis to the parent optically active drug is not necessary prior to dosing the patient since the compound can behave as a prodrug. The optically active compounds of Formula I can likewise be obtained by utilizing optically active starting materials.

Contemplated equivalents of the general formulas set forth above for the MMP inhibitor compounds and derivatives as well as the intermediates are compounds otherwise corresponding thereto and having the same general properties such as tautomers thereof and compounds wherein one or more of the various R groups are simple variations of the substituents as defined therein, e.g., wherein R is a higher alkyl group than that indicated. In addition, where a substituent is designated as, or can be, a hydrogen, the exact chemical nature of a substituent which is other than hydrogen at that position, e.g., a hydrocarbyl radical or a halogen, hydroxy, amino and the like functional group, is not critical so long as it does not adversely affect the overall activity and/or synthesis procedure. For example, two hydroxyl groups, two amino groups, two thiol groups or a mixture of two hydrogen-heteroatom groups on the same carbon are know not to be stable without protection or as a derivative.

The chemical reactions described above are generally disclosed in terms of their broadest application to the preparation of the compounds of this invention. Occasionally, the reactions may not be applicable as

described to each compound included within the disclosed scope. The compounds for which this occurs will be readily recognized by those skilled in the art. In all such cases, either the reactions can be successfully performed by conventional modifications known to those skilled in the art, e.g., by appropriate protection of interfering groups, by changing to alternative conventional reagents, by routine modification of reaction conditions, and the like, or other reactions disclosed herein or otherwise conventional, will be applicable to the preparation of the corresponding compounds of this invention. In all preparative methods, all starting materials are known or can be readily prepared from known starting materials.

d. Treatment Methods

A process for treating a host mammal having a condition associated with pathological matrix metalloproteinase activity is also contemplated. That process comprises administering a metalloproteinase inhibitor described hereinbefore in an MMP enzyme-inhibiting effective amount to a mammalian host having such a condition. The use of administration repeated a plurality of times is particularly contemplated.

A contemplated inhibitor compound is used for treating a host mammal such as a mouse, rat, rabbit, dog, horse, primate such as a monkey, chimpanzee or human that has a condition associated with pathological matrix metalloproteinase activity.

Also contemplated is the similar use of a contemplated metalloproteinase inhibitor compound in the treatment of a disease state that can be affected by the activity of metalloproteinases such as TNF-α convertase. Exemplary of such disease states are the acute phase responses of shock and sepsis, coagulation responses,

hemorrhage and cardiovascular effects, fever and inflammation, anorexia and cachexia.

In treating a disease condition associated with pathological matrix metalloproteinase activity, a contemplated MMP inhibitor compound can be used, where appropriate, in the form of an amine salt derived from an inorganic or organic acid. Exemplary acid salts include but are not limited to the following: acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate and undecanoate.

Also, a basic nitrogen-containing group can be quaternized with such agents as lower alkyl (C_1-C_6) halides, such as methyl, ethyl, propyl, and butyl chloride, bromides, and iodides; dialkyl sulfates like dimethyl, diethyl, dibuytl, and diamyl sulfates, long chain (C_8-C_{20}) halides such as decyl, lauryl, myristyl and dodecyl chlorides, bromides and iodides, aralkyl halides like benzyl and phenethyl bromides, and others to provide enhanced water-solubility. Water or oil-soluble or dispersible products are thereby obtained as desired. The salts are formed by combining the basic compounds with the desired acid.

Other compounds useful in this invention that are acids can also form salts. Examples include salts with alkali metals or alkaline earth metals, such as sodium,

potassium, calcium or magnesium or with organic bases or basic quaternary ammonium salts.

In some cases, the salts can also be used as an aid in the isolation, purification or resolution of the compounds of this invention.

Total daily dose administered to a host mammal in single or divided doses of an MMP enzyme-inhibiting effective amount can be in amounts, for example, of about 0.001 to about 30 mg/kg body weight daily and more usually about 0.01 to about 10 mg. Dosage unit compositions can contain such amounts or submultiples thereof to make up the daily dose. A suitable dose can be administered, in multiple sub-doses per day. Multiple doses per day can also increase the total daily dose, should such dosing be desired by the person prescribing the drug.

The dosage regimen for treating a disease condition with a compound and/or composition of this invention is selected in accordance with a variety of factors, including the type, age, weight, sex, diet and medical condition of the patient, the severity of the disease, the route of administration, pharmacological considerations such as the activity, efficacy, pharmacokinetic and toxicology profiles of the particular compound employed, whether a drug delivery system is utilized and whether the compound is administered as part of a drug combination. Thus, the dosage regimen actually employed can vary widely and therefore can deviate from the preferred dosage regimen set forth above.

A compound useful in the present invention can be formulated as a pharmaceutical composition. Such a composition can then be administered orally, parenterally, by inhalation spray, rectally, or topically in dosage unit formulations containing conventional nontoxic pharmaceutically acceptable

carriers, adjuvants, and vehicles as desired. Topical administration can also involve the use of transdermal administration such as transdermal patches or iontophoresis devices. The term parenteral as used herein includes subcutaneous injections, intravenous, intramuscular, intrasternal injection, or infusion techniques. Formulation of drugs is discussed in, for example, Hoover, John E., Remington's Pharmaceutical Sciences, Mack Publishing Co., Easton, Pennsylvania; 1975 and Liberman, H.A. and Lachman, L., Eds., Pharmaceutical Dosage Forms, Marcel Decker, New York, N.Y., 1980.

Injectable preparations, for example, sterile injectable aqueous or oleaginous suspensions can be formulated according to the known art using suitable dispersing or wetting agents and suspending agents. The sterile injectable preparation can also be a sterile injectable solution or suspension in a nontoxic parenterally acceptable diluent or solvent, for example, as a solution in 1,3-butanediol. Among the acceptable vehicles and solvents that can be employed are water, Ringer's solution, and isotonic sodium chloride solution. In addition, sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose any bland fixed oil can be employed including synthetic mono- or diglycerides. In addition, fatty acids such as oleic acid find use in the preparation of injectables. Dimethyl acetamide, surfactants including ionic and non-ionic detergents, polyethylene glycols can be used. Mixtures of solvents and wetting agents such as those discussed above are also useful.

Suppositories for rectal administration of the drug can be prepared by mixing the drug with a suitable nonirritating excipient such as cocoa butter, synthetic mono-, di-, or triglycerides, fatty acids and

polyethylene glycols that are solid at ordinary temperatures but liquid at the rectal temperature and will therefore melt in the rectum and release the drug.

Solid dosage forms for oral administration can include capsules, tablets, pills, powders, and granules. In such solid dosage forms, the compounds of this invention are ordinarily combined with one or more adjuvants appropriate to the indicated route of administration. If administered *per os*, the compounds can be admixed with lactose, sucrose, starch powder, cellulose esters of alkanoic acids, cellulose alkyl esters, talc, stearic acid, magnesium stearate, magnesium oxide, sodium and calcium salts of phosphoric and sulfuric acids, gelatin, acacia gum, sodium alginate, polyvinylpyrrolidone, and/or polyvinyl alcohol, and then tableted or encapsulated for convenient administration. Such capsules or tablets can contain a controlled-release formulation as can be provided in a dispersion of active compound in hydroxypropylmethyl cellulose. In the case of capsules, tablets, and pills, the dosage forms can also comprise buffering agents such as sodium citrate, magnesium or calcium carbonate or bicarbonate. Tablets and pills can additionally be prepared with enteric coatings.

For therapeutic purposes, formulations for parenteral administration can be in the form of aqueous or non-aqueous isotonic sterile injection solutions or suspensions. These solutions and suspensions can be prepared from sterile powders or granules having one or more of the carriers or diluents mentioned for use in the formulations for oral administration. The compounds can be dissolved in water, polyethylene glycol, propylene glycol, ethanol, corn oil, cottonseed oil, peanut oil, sesame oil, benzyl alcohol, sodium chloride, and/or various buffers. Other adjuvants and modes of

administration are well and widely known in the pharmaceutical art.

Liquid dosage forms for oral administration can include pharmaceutically acceptable emulsions, solutions, suspensions, syrups, and elixirs containing inert diluents commonly used in the art, such as water. Such compositions can also comprise adjuvants, such as wetting agents, emulsifying and suspending agents, and sweetening, flavoring, and perfuming agents.

The amount of active ingredient that can be combined with the carrier materials to produce a single dosage form varies depending upon the mammalian host treated and the particular mode of administration.

Certain of the sulfonamide, sulfinamide or sulfenamide, compounds of this invention that are administered in accordance with an above-discussed process can serve as prodrugs to other compounds of this invention. Prodrugs are drugs that can be chemically converted *in vivo* or *in vitro* by biological systems into an active derivative or derivatives. Prodrugs are administered in essentially the same manner as the other pharmaceutical compounds of the invention.

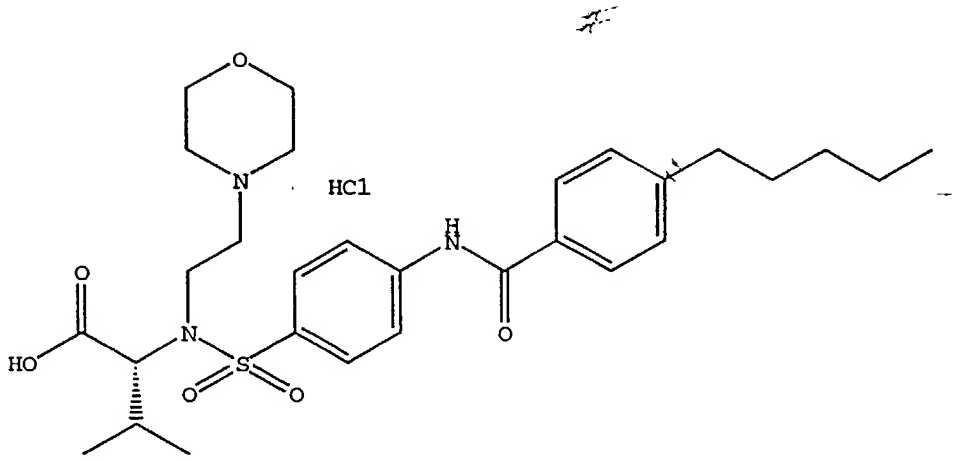
e. Detailed Preparative and Crystallographic Methods

The starting materials for use in the methods of preparation of the invention are known or can be prepared by conventional methods known to a skilled person or in an analogous manner to processes described in the art.

Generally, the process methods of the present invention can be performed as follows.

Example 1.

N-[2-(4-morpholinyl)ethyl]-N-[[4-[(4-pentylbenzoyl)amino]phenyl]sulfonyl]-D-valine (IX)



Part A: To a solution of D-valine (25.0 g, 213 mmol) in H_2O (180 mL) and acetone (96 mL) was added triethylamine (62 mL, 448 mmol) and was cooled to zero degrees Celsius. To this solution was added 4-nitrobenzenesulfonyl chloride (45.3 g, 204 mmol) in acetone (100 mL) dropwise. The solution was stirred for 72 hours. The solution was concentrated *in vacuo* and the resulting aqueous layer was extracted with toluene and acidified to pH = 2 with 2N HCl. The aqueous layer was extracted with ethyl acetate three times and the combined organic layers were washed with saturated NaCl and dried over $MgSO_4$. Concentration *in vacuo* provided the sulfonamide as a light brown solid (37.15 g, 61 %).

Part B: A solution of the sulfonamide of part A (37.15 g, 123 mmol) and a catalytic amount of H_2SO_4 in dichloromethane/dioxane (1L) was subjected to isobutylene for 18 hours. The solution was cooled to zero degrees Celsius and quenched with saturated $NaHCO_3$. The aqueous layer was extracted with ethyl acetate and the organic layer was washed with saturated NaCl and dried over $MgSO_4$. Chromatography (on silica, ethyl acetate/hexane) provided the t-butyl ester as a solid (16.7 g, 38 %).

Part C: To a solution of the t-butyl ester of part B (16.5 g, 46 mmol) in DMF (60 mL) was added 4-(2-chloroethyl) morpholine hydrochloride (17.2 g, 92 mmol) and K_2CO_3 (25.5 g, 184 mmol) and the solution was heated to sixty degrees Celsius for 7 hours. The solution was partitioned between ethyl acetate and H_2O and the organic layer was washed with saturated NaCl and dried over Na_2SO_4. Chromatography (on silica, ethyl acetate/hexane) provided the morpholine compound as a solid (21.5 g, 99 %).

Part D: To a solution of the morpholine compound of part C (21.5 g, 45.6 mmol) in THF (200 mL) in a flask purged with H_2 was added 4% Pd/C (3.04 g) and the solution was hydrogenated until uptake ceased. The solution was filtered through Celite® to remove the excess catalyst and the filtrate was concentrated *in vacuo* to provide the aniline as an oil (19.2 g, 95 %).

Part E: To a solution of the aniline of part D (2.60 g, 5.88 mmol) in THF (20 mL) was added triethylamine (3.2 mL, 22.8 mmol) and the solution was cooled to four degrees Celsius. To this solution was added 4-pentylbenzoyl chloride (2.1 g, 10.0 mmol) and the solution was stirred for 18 hours at ambient temperature. The solution was concentrated *in vacuo* and the residue was partitioned between ethyl acetate and saturated $NaHCO_3$. The organic layer was washed with saturated $NaHCO_3$ and saturated NaCl and dried over Na_2SO_4. Chromatography (ethyl acetate/hexane) provided the benzamide as a solid (2.09 g, 58 %).

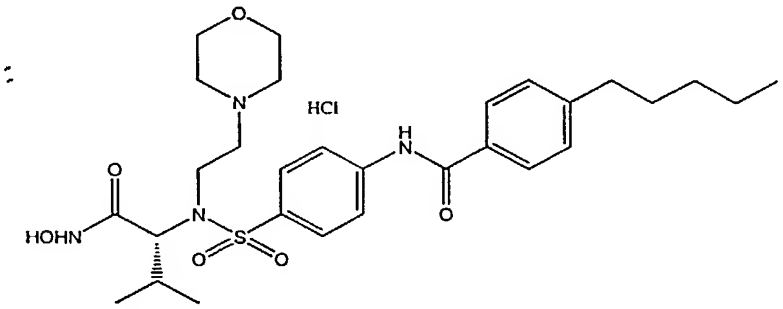
Part F: A solution of the benzamide of part E (2.09 g, 3.4 mmol) in 4N HCl (20 mL) was stirred for 72 hours. The solution was concentrated *in vacuo* and the residue was dissolved into ethyl acetate (5 mL) and dropped into ethyl ether. The resulting precipitate was collected by vacuum filtration to provide R-N-[4-[[[1-carboxyl]-2-methylpropyl][2-(4-orpholinyl)ethyl]amino]-

sulfonyl]phenyl]-4-pentylbenzamide monohydrochloride as a white solid (1.9 g, 94 %).

MS(CI) MH^+ calculated for $C_{29}H_{41}N_3O_6S$: 560, found: 560.

Example 2.

R-N-[4-[[[1-(hydroxyamino)carbonyl]-2-methylpropyl][2-(4-morpholinyl)ethyl]amino]-sulfonyl]phenyl]-4-pentylbenzamide, monohydrochloride (X)



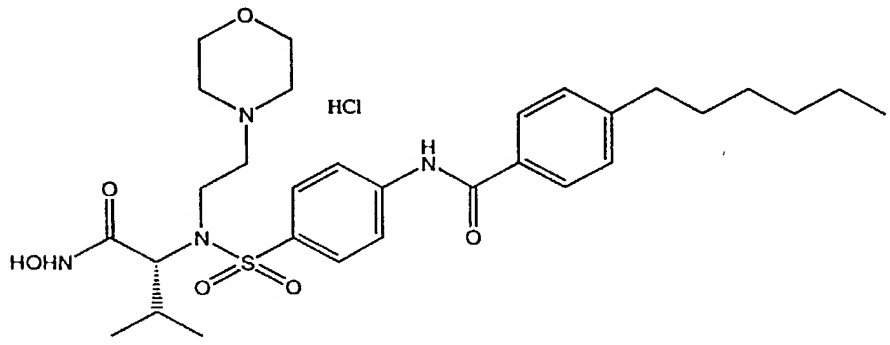
Part A: To a solution of the acid of Example 1, part F (1.52 g, 2.56 mmol) in DMF (5 mL) was added N-hydroxybenzotriazole (414 mg, 3.07 mmol) and the solution was cooled to four degrees Celsius. To this solution was added 4-methylmorpholine (1.69 mL, 15.6 mmol), 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (687 mg, 3.58 mmol) and tetrahydropyranyl hydroxylamine (449 mg, 3.84 mmol) and was stirred for 1 hour at ambient temperature. The solution was partitioned between ethyl acetate and saturated $NaHCO_3$ and the organic layer was washed with saturated $NaHCO_3$, saturated NaCl and H_2O and dried over Na_2SO_4. Chromatography (ethyl acetate/methanol) provided the ester as a solid (1.54 g, 91 %).

Part B: To a solution of the ester of part A (1.54 g, 2.34 mmol) in methanol (1 mL) was added 4N HCl (10 mL) and the solution was stirred for 18 hours at ambient

temperature. The solution was concentrated *in vacuo*. Reverse phase chromatography (on silica, acetonitrile/H_2O(HCl) provided the title compound, R-N-[4-[[[1-(hydroxyamino)carbonyl]-2-methylpropyl][2-(4-morpholinyl)ethyl]amino]sulfonyl]phenyl]-4-pentylbenzamide, monohydrochloride, as a white solid (745 mg, 52 %). MS(CI) MH^+ calculated for $C_{29}H_{42}N_4O_6S$: 575, found: 575.

Example 3.

(R)-4-hexyl-N-[4-[[[1-(hydroxyamino)-carbonyl]-2-methylpropyl][2-(4-morpholinyl)ethyl]amino]sulfonyl]-phenylbenzamide, monohydrochloride (XI)



Part A: To a solution of the aniline of Example 1, part D (2.5 g, 5.7 mmol) was added triethylamine (3.2 mL, 22.8 mmol) and the solution was cooled to four degrees Celsius. To this solution was added 4-hexylbenzoyl chloride (2.18 g, 9.69 mmol) and the solution was stirred overnight at ambient temperature. The solution was concentrated *in vacuo* and the residue was partitioned between ethyl acetate and saturated $NaHCO_3$. The organic layer was washed with saturated $NaHCO_3$ and saturated NaCl and dried over Na_2SO_4. Chromatography (on silica, ethyl acetate/hexane) provided the benzamide as a solid (2.76 g, 77 %).

Part B: A solution of the benzamide of part A (2.7 g, 4.3 mmol) in 4N HCl in dioxane (20 mL) was stirred for 72 hours. The solution was concentrated *in vacuo* and the residue was dissolved into ethyl acetate (5 mL). This solution was dropped into ethyl ether. The resulting precipitate was collected by vacuum filtration to provide the acid as a solid (2.5 g, 95 %).

Part C: To a solution of the acid of part B (2.03 g, 3.33 mmol) in DMF (5 mL) was added N-hydroxybenzotriazole (540 mg, 4.00 mmol) and the solution was cooled to four degrees Celsius. To this solution was added 4-methylmorpholine (2.19 mL, 20.0 mmol), 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (894 mg, 4.66 mmol) and tetrahydropyranyl hydroxylamine (615 mg, 5.00 mmol) and the solution was stirred for 1 hour at ambient temperature. The solution was partitioned between ethyl acetate and saturated $NaHCO_3$ and the organic layer was washed with saturated $NaHCO_3$, saturated NaCl and H_2O and dried over $Na2SO_4$. Chromatography (on silica, ethyl acetate/methanol) provided the ester as a solid (2.01 g, 90 %).

Part D: To a solution of the ester of part C (2.01 g, 3.24 mmol) in methanol (1 mL) was added 4N HCl (10 mL) and the solution was stirred for 18 hours at ambient temperature. Reverse phase chromatography (on silica, acetonitrile/H_2O(0.05% HCl)) provided the title compound, (R)-4-hexyl-N-[4-[[[1-(hydroxyamino)carbonyl]-2-methylpropyl][2-(4-morpholinyl)ethyl]amino]sulfonyl]-phenylbenzamide, monohydrochloride, as a white solid (1.23 g, 61 %). MS(CI) MH^+ calculated for $C_{30}H_{44}N_4O_6S$: 589, found: 589.

Example 4.

Cloning, expression and purification of the catalytic domain of MMP-8.

The MMP-8 catalytic domain was cloned by PCR amplification from a cDNA contruct of full-length MMP-8. The amplified DNA was cloned into NdeI/HindIII restriction sites in an in-house pRec expression vector. Protein was expressed in a bacterial expression system by induction with nalidixic acid. Recombinant protein was expressed primarily as inclusion bodies. Purified protein was recovered in high yield following ion exchange chromatography of denatured protein. Refolding from denaturant and subsequent purification using a second ion exchange step resulted in active protein that was used for crystallography.

Crystallization of inhibitor complexes.

Crystals were grown by vapor equilibration in sitting drops following a procedure similar to that described by Bode *et al.* ("The X-ray crystal structure of the catalytic domain of human neutrophil collagenase inhibited by a substrate analogue reveals the essentials for catalysis and specificity," *FEBS Letters* **338**, 227-233 (1994).) A solution of the enzyme inhibitor complex is mixed with a precipitating reagent to form the sitting drop which is equilibrated against a high-salt solution. Slow dehydration of the drop leads to formation of single crystals of the inhibitor complex. Details are below.

Protein: 12 mg/ml MMP-8 in 10 mM MES pH 6.0, 100 mM NaCl, 5 mM $CaCl_2$ pre-incubated with 1 mM inhibitor for 10 minutes at ambient temperature.

Sitting Drop: 4 ul of the protein-inhibitor complex mixed with 6.8 ul 10% PEG6000 and 0.2 M MES pH 6.0

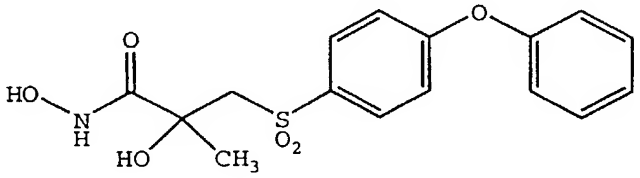
Reservoir: 0.8 to 2.5 M sodium/potassium phosphate pH 6.0 (not mixed with protein/inhibitor/PEG drop).

X-ray Data Collection.

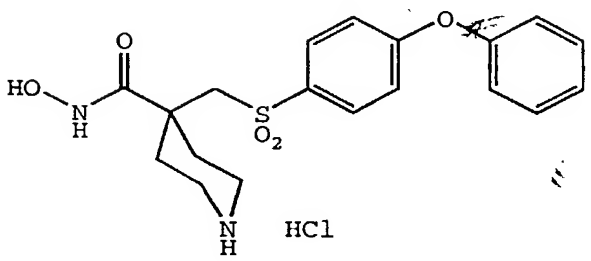
Intensities from crystals of the enzyme inhibitor complexes were measured on a MAR image plate at -140 °C. X-rays were generated from a rotating anode generator using a Cu target. The CuK_α X-rays were focused onto the samples using long Pt and Ni mirrors.

The data were integrated and scaled using the program DENZO (Otwinowski, Z. and Minor W. in *Proceedings of CCP4 Study Weekend: Data Collection and Processing* (eds. Sawyer, L., Issacs, N., and Bailey, S.) pp. 56-62 (SERC Daresbury Laboratories, Warrington, UK 1993)).

The structures for compounds XIV and XV are shown below. Compound XIV is described in U.S. Patent Application No. 09/254,535, herein incorporated by reference. Compound XV is described in U.S. Patent Application No. 09/254,530, herein incorporated by reference.



Formula XIV



Formula XV

Statistics for six data sets are given in the Tables II and III below:

Space Group: $P2_12_12_1$

Table II

Compound with which MMP-8 catalytic domain (residues 85-242) are com-plexed[a]	a[b]	b[b]	c[b]	Res-olu-tion[c]	Rsym[d]	I/sig[e]
XII	32.97	68.92	70.61	1.65	0.050(0.209)	21.8(3.4)
IX	33.05	68.59	68.55	1.64	0.078(0.326)	10.9(1.7)
X	33.50	68.79	69.34	1.65	0.084(0.257)	12.4(2.7)
XI	33.31	68.50	67.01	1.83	0.097(0.467)	14.2(2.9)
XIV	32.43	68.16	72.08	1.46	0.029(0.078)	25.6(11.9)
XV	32.40	68.26	71.70	1.43	0.079(0.307)	15.9(2.4)

Table III

Compound with which MMP-8 catalytic domain (residues 85-242) are complexed[a]	total[f]	unique[g]	redundant[h]	coverage[i]
XII	52840	18220	2.9	90.7(66.8)
IX	42171	17815	2.4	90.9(76.1)
X	39481	15999	2.5	87.2(80.6)

XI	46758	14042	3.3	97.6(97.3)
XIV	70996	26770	2.5	93.8(82.5)
XV	107545	29122	3.7	96.4(87.3)

[a]Inhibitor code;

[b]lattice constants (unit cell dimensions).

[c]data resolution;

[d]Rsym (internal consistency) for overall and highest resolution shell;

[e]I/sigma (signal/noise ratio) for overall and highest resolution shell;

[f]total number of observations collected;

[g]number of unique reflections;

[h]redundancy;

[i]data coverage (completeness in %) for overall and highest resolution shell.

Structure Solution and Model Building and Refinement.

Coordinates of the structure of MMP-8 in complex with batimastat (4-(N-hydroxyamino)-2R-isobutyl-2S-(2-thienylthiomethyl)succinyl-L-phenylalanine-N-methylamide) were obtained from the Protein Data Bank (accession number: 1mmb) Coordinates of only the protein atoms and the metal ions were used in an initial refinement with the X-ray data collected on the new complexes. Standard simulated annealing protocols in the program XPLOR (Brünger, A.T. (1993). *XPLOR (Version 3.1): A System for X-ray Crystallography and NMR* (Yale University Press, New Haven, CT)) were used. The refined positional and thermal parameters were used to calculate new phases for display of Fo-Fc and 2Fo-Fc electron density maps; the program XPLOR was also used for calculation of the maps which were displayed on a Silicon Graphics terminal using the program O (Jones, T.A., Zou, J.Y., Cowan, S.W. and Kjeldgarrd, M. (1991). "Improved methods for binding protein models in electron

density maps and the location of errors in these models," *Acta Crystallogr.* **A47**, 110-119).

New electron density at the expected active site could in all cases be interpreted with flexible, three-dimensional models of the inhibitors as generated in the program INSIGHTII (Biosym Technologies (1993). Insight II User Guide, Version 2.2.0. San Diego). Solvent positions were also identified from these electron density maps and side chains of the protein were also sometimes manually adjusted.

Final refinements of the structure were carried out with inclusion of inhibitor and solvent ligands. In the refinements, 10% of the data was set aside for cross validation by evaluation of R_{free} (A.T. Brünger, "Free R Value: a novel statistical quantity for accessing the accuracy of crystal structures," *Nature* **355**, 472-475 (1992)). Results are shown in the Table IV.

Table IV.

Compound with which MMP-8 catalytic domain (residues 85-242) is complexed[a]	Res-olution[j]	R_{free}/R_{work}[k]	Reflec-tion[m]	rms Bond[n]	rms Angle[p]
XII	8.00-1.65	0.249(0.290)/ 0.187(0.284)	17419	0.01	1.6
IX	8.00-1.64	0.286(0.370)/ 0.188(0.323)	15052	0.01	1.7
X	8.00-1.69	0.276(0.283)/ 0.195(0.271)	14239	0.02	2.0
XI	8.00-1.83	0.262(0.376)/ 0.168(0.225)	12019	0.02	1.9
XIV	8.00-1.46	0.222(0.215)/ 0.181(0.215)	26180	0.01	1.7
XV	8.00-1.43	0.208(0.232)/ 0.174(0.247)	26617	0.01	1.7

[a]Inhibitor code.

[j]resolution (in angstroms).

[k]number of reflections.

[m]R_{work}/R_{free} for overall and highest resolution shell

[n]RMS deviation in bond lengths (in angstroms).

[p]RMS deviation in covalent bond angles (in degrees).

In the case of Formula XIII, we noticed that the refinement yielded an unexpected conformation for the side chain of Arg 222. Display of the electron density maps verified the new position for this residue. Analysis of the structure also revealed that retention of the previously observed conformation of this residue would have led to steric clash with the P1' moiety of the inhibitor.

In the cases of Formulas IX, X and XI, the refinement yielded a completely new position for Tyr 227 in addition to the perturbed Arg 222 side chain. The new Tyr position was resulted from a major movement backbone and sidechains for residues 224-229. Display of the electron density maps verified the new position for this residue. Analysis of the structure also revealed that retention of the previously observed conformations of this residues would have led to steric clash between the side chain of Tyr 227 and the P1' moiety of the inhibitor.

The combination of the swerve of Arg 222 side chain and the conformation changes in residues 224-229 essentially opens up the enzyme S1' pocket. In this new form, inhibitors with longer (equivalent to seven and more carbon chains beyond the second ring) and bigger P1' ($-CF_3$, $-(C_6H_4)-$, etc.) moieties can be accommodated. Two factors govern the inhibitor P1' moiety: it has to be nonpolar (a single polar $-NH_2$ group has been shown tolerable) to pass through the highly hydrophobic S1'

pocket of the enzyme and it has to have some exposed polar groups when the chain is long enough to protrude itself out to the hydrophilic solvent region.

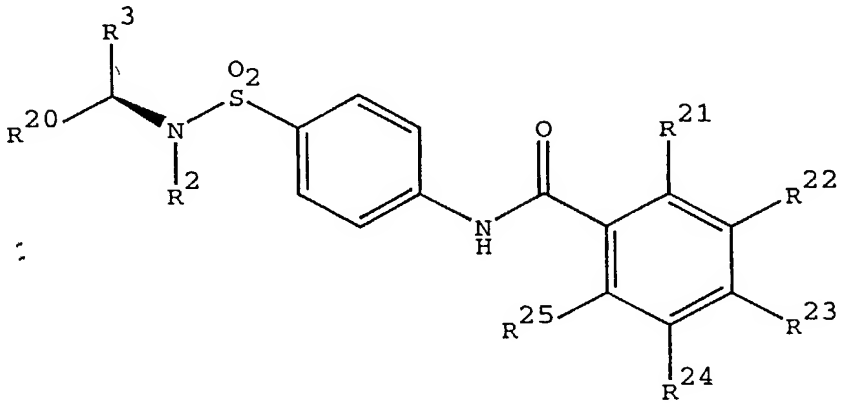
The examples herein can be performed by substituting the generically or specifically described reactants and/or operating conditions of this invention for those used in the preceding examples.

The invention being thus described, it is apparent that the same can be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the present invention, and all such modifications and equivalents as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

CLAIMS

What is claimed is:

1. A matrix metalloproteinase inhibiting compound having the structure:



or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof, wherein:

R^2 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, and heterocycloalkylalkyl;

R^3 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, haloalkoxy, haloalkylthio, and heterocycloalkyl;

R^{20} is selected from the group consisting of -C(O)OH, -C(O)NHOH, -SH, and -C(O)SH; and

R^{21}, R^{22}, R^{23}, R^{24}, and R^{25} are independently selected from the group consisting of H, C_1 to about C_{20} alkyl, C_1 to about C_{20} alkenyl, C_1 to about C_{20} alkynyl, cycloalkyl, haloalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl,

alkylaminoalkyl, nitroalkyl, heterocycloalkyl, alkoxy, cycloalkoxy, alkoxycarbonyl, alkoxyalkyl, haloalkoxy, haloalkylthio, alkylamino, and carboxyalkyl.

2. The matrix metalloproteinase inhibiting compound of claim 1 wherein R^{20} is selected from the group consisting of -C(O)OH and -C(O)NHOH.

3. The matrix metalloproteinase inhibiting compound of claim 2 wherein R^{21} and R^{25} are H.

4. The matrix metalloproteinase inhibiting compound of claim 3 wherein R^{22} and R^{24} are H.

5. The matrix metalloproteinase inhibiting compound of claim 4 wherein R^{23} is C_1 to about C_{20} alkyl.

6. The matrix metalloproteinase inhibiting compound of claim 5 wherein R^{23} is C_1 to about C_{20} linear alkyl.

7. The matrix metalloproteinase inhibiting compound of claim 2 wherein R^{20} is -C(O)OH.

8. The matrix metalloproteinase inhibiting compound of claim 7 wherein R^3 is selected from the group consisting of alkyl, alkenyl, alkynyl, haloalkoxy, haloalkylthio, and heterocycloalkyl.

9. The matrix metalloproteinase inhibiting compound of claim 8 wherein R^3 is heterocycloalkyl.

10. The matrix metalloproteinase inhibiting compound of claim 9 wherein R^3 is 2-(N-morpholino)ethyl.

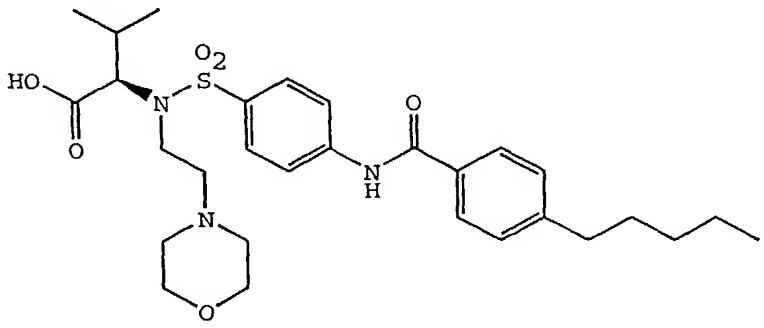
11. The matrix metalloproteinase inhibiting compound of claim 2 wherein R^{20} is -C(O)NHOH.

12. The matrix metalloproteinase inhibiting compound of claim 11 wherein R^3 is selected from the group consisting of alkyl, alkenyl, alkynyl, haloalkoxy, haloalkylthio, and heterocycloalkyl.

13. The matrix metalloproteinase inhibiting compound of claim 12 wherein R^3 is heterocycloalkyl.

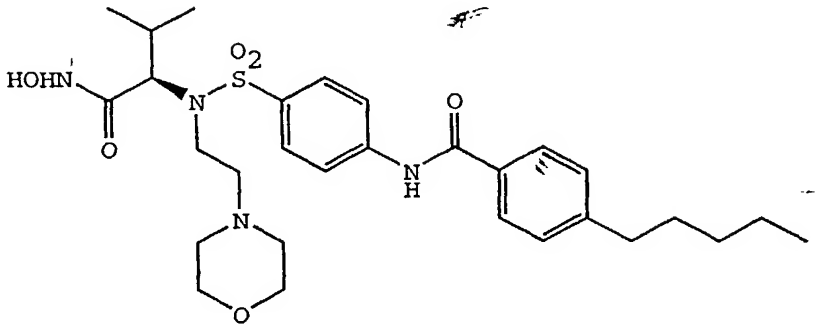
14. The matrix metalloproteinase inhibiting compound of claim 13 wherein R^3 is 2-(N-morpholino)ethyl.

15. The matrix metalloproteinase inhibiting compound of claim 14 having the structure



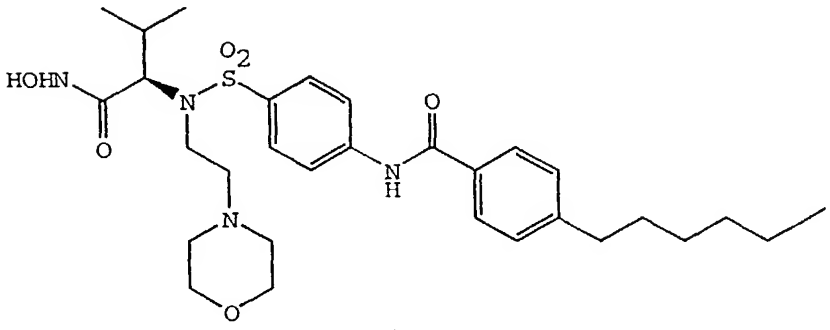
or a salt, an enantiomer, a racemate, or a tautomer thereof.

16. The matrix metalloproteinase inhibiting compound of claim 14 having the structure



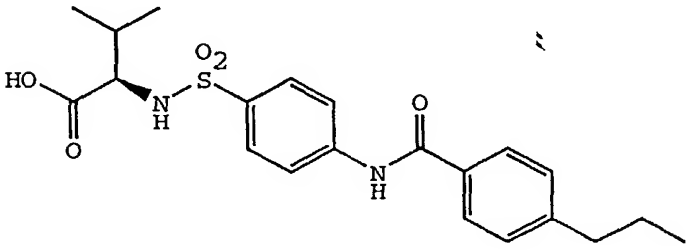
or a salt, an enantiomer, a racemate, or a tautomer thereof.

17. The matrix metalloproteinase inhibiting compound of claim 14 having the structure



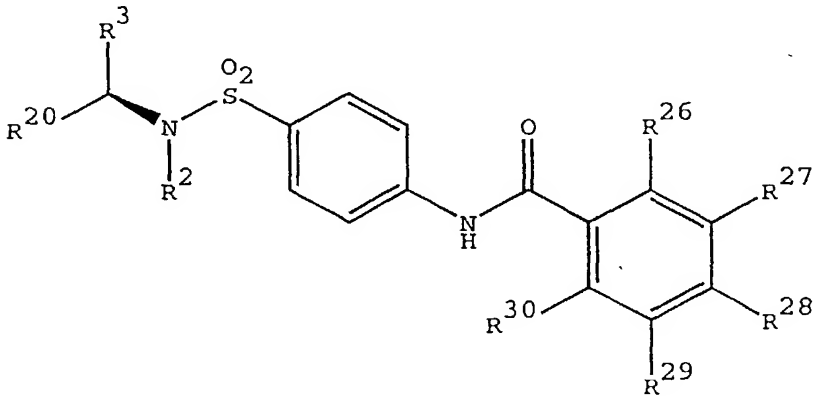
or a salt, an enantiomer, a racemate, or a tautomer thereof.

18. The matrix metalloproteinase inhibiting compound of claim 14 having the structure



or a salt, an enantiomer, a racemate, or a tautomer thereof.

19. A method of changing the conformation of a matrix metalloproteinase wherein the method comprises contacting the matrix metalloproteinase with a compound having the formula:



or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof, thereby changing the conformation of the matrix metalloproteinase, wherein:

R^2 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl,

alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, and heterocycloalkylalkyl;

R^3 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, haloalkoxy, haloalkylthio, and heterocycloalkyl;

R^{20} is selected from the group consisting of -C(O)OH, -C(O)NHOH, -SH, and -C(O)SH; and

R^{26}, R^{27}, R^{28}, R^{29}, and R^{30} are independently selected from the group consisting of about C_3 to about C_{20} alkyl, about C_3 to about C_{20} alkenyl, about C_3 to about C_{20} alkynyl, cycloalkyl, haloalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, nitroalkyl, heterocycloalkyl, alkoxy, cycloalkoxy, alkoxycarbonyl, alkoxyalkyl, haloalkoxy, haloalkylthio, alkylamino, and carboxyalkyl.

20. The method of claim 19 wherein R^{20} is selected from the group consisting of -C(O)OH and -C(O)NHOH.

21. The method of claim 19 wherein R^3 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, haloalkoxy, haloalkylthio, and heterocycloalkyl

22. The method of claim 21 wherein R^3 is a C_1 to about C_{12} alkyl.

23. The method of claim 22 wherein R^3 is a C_1 to about C_4 alkyl.

24. The method of claim 23 wherein R^3 is isopropyl.

25. The method of claim 19 wherein R^2 is heterocycloalkylalkyl.

26. The method of claim 25 wherein R^3 is 2-(N-morpholino)ethyl.

27. The method of claim 19 wherein R^{26} and R^{30} are H.

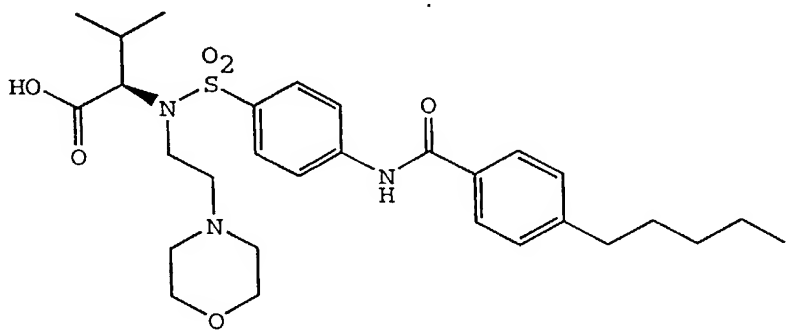
28. The method of claim 27 wherein R^{27} and R^{29} are H.

29. The method of claim 28 wherein R^{28} is about C_3 to about C_{20} alkyl.

30. The method of claim 29 wherein R^{28} is about C_3 to about C_{20} linear alkyl.

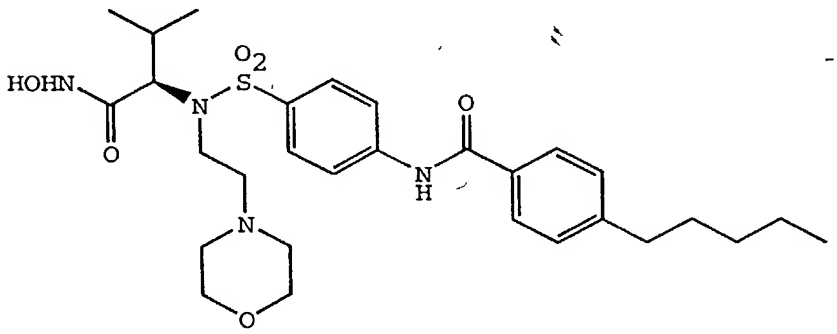
31. The method of claim 30 wherein R^{28} is selected from the group consisting of n-propyl, n-butyl, n-pentyl and n-hexyl.

32. The method of claim 31 wherein the compound has the structure:



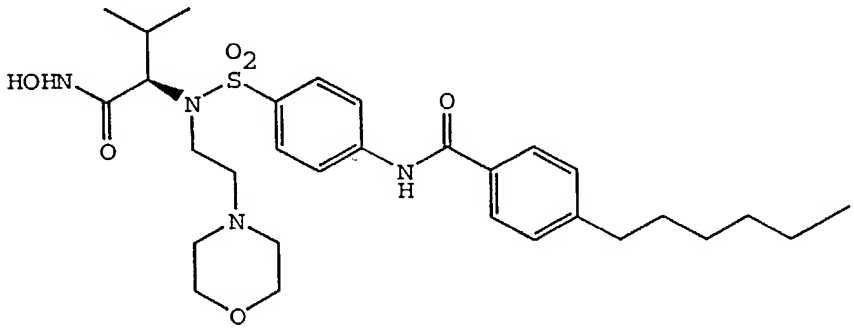
or a salt, an enantiomer, a racemate, or a tautomer thereof.

33. The method of claim 31 wherein the compound has the structure:



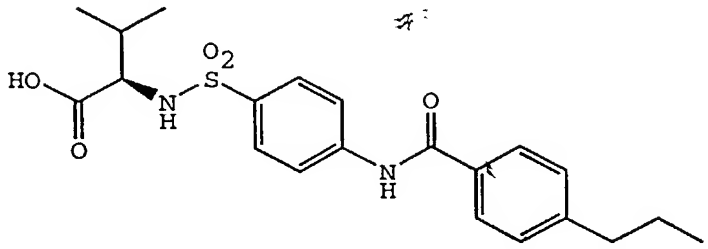
or a salt, an enantiomer, a racemate, or a tautomer thereof.

34. The method of claim 31 wherein the compound has the structure:



or a salt, an enantiomer, a racemate, or a tautomer thereof.

35. The method of claim 31 wherein the compound has the structure:



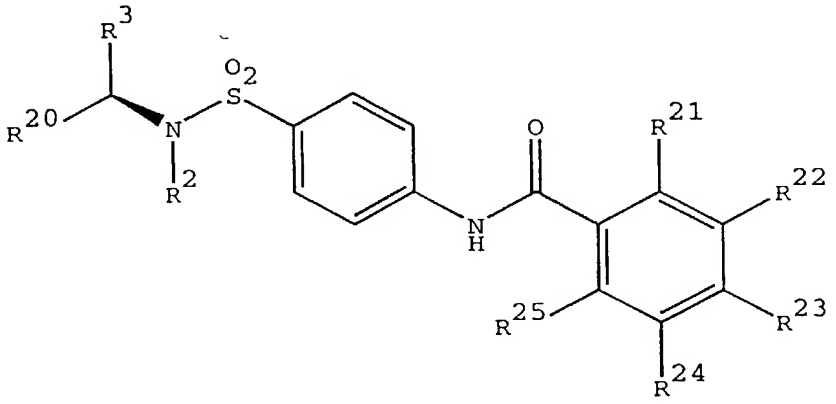
or a salt, an enantiomer, a racemate, or a tautomer thereof.

36. The method of claim 19 wherein the matrix metalloproteinase is selected from the group consisting of MMP-8 and MMP-13.

37. The method of claim 36 wherein the matrix metalloproteinase is MMP-8.

38. The method of claim 36 wherein the matrix metalloproteinase is MMP-13.

39. A method of inhibiting a matrix metalloproteinase wherein the method comprises contacting the matrix metalloproteinase with a compound having the formula:



or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof, thereby inhibiting the matrix metalloproteinase, wherein:

R^2 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, and heterocycloalkylalkyl;

R^3 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, haloalkoxy, haloalkylthio, and heterocycloalkyl;

R^{20} is selected from the group consisting of -C(O)OH, -C(O)NHOH, -SH, and -C(O)SH; and

R^{21}, R^{22}, R^{23}, R^{24}, and R^{25} are independently selected from the group consisting of H, C_1 to about C_{20} alkyl, C_1 to about C_{20} alkenyl, C_1 to about C_{20} alkynyl, cycloalkyl, haloalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, nitroalkyl, heterocycloalkyl, alkoxy, cycloalkoxy, alkoxycarbonyl, alkoxyalkyl, haloalkoxy, haloalkylthio, alkylamino, and carboxyalkyl.

40. The method of claim 39 wherein R^{20} is selected from the group consisting of -C(O)OH and -C(O)NHOH.

41. The method of claim 39 wherein R^3 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, haloalkoxy, haloalkylthio, and heterocycloalkyl.

42. The method of claim 41 wherein R^3 is a C_1 to about C_{12} alkyl.

43. The method of claim 42 wherein R^3 is a C_1 to about C_4 alkyl.

44. The method of claim 43 wherein R^3 is isopropyl.

45. The method of claim 39 wherein R^2 is heterocycloalkylalkyl.

46. The method of claim 45 wherein R^2 is 2-(N-morpholino)ethyl.

47. The method of claim 39 wherein R^{21} and R^{25} are H.

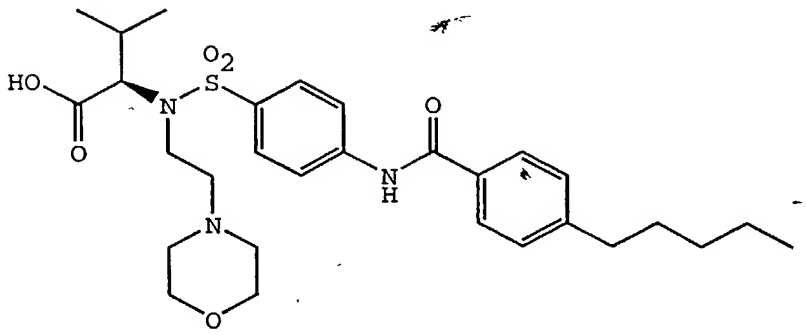
48. The method of claim 47 wherein R^{22} and R^{24} are H.

49. The method of claim 48 wherein R^{23} is C_1 to about C_{20} alkyl.

50. The method of claim 49 wherein R^{23} is methyl or C_2 to about C_{20} linear alkyl.

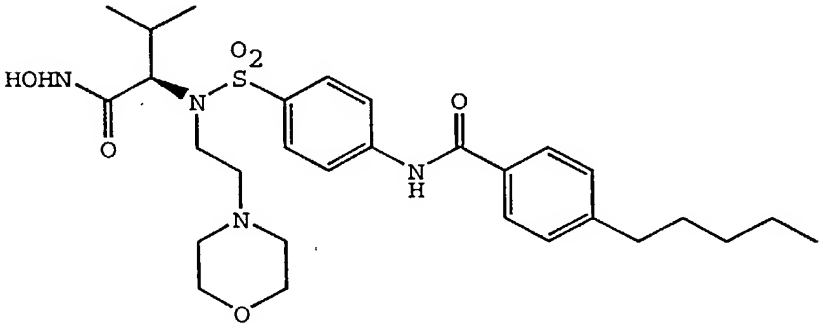
51. The method of claim 50 wherein R^{23} is n-pentyl or n-hexyl.

52. The method of claim 51 wherein the compound has the structure:



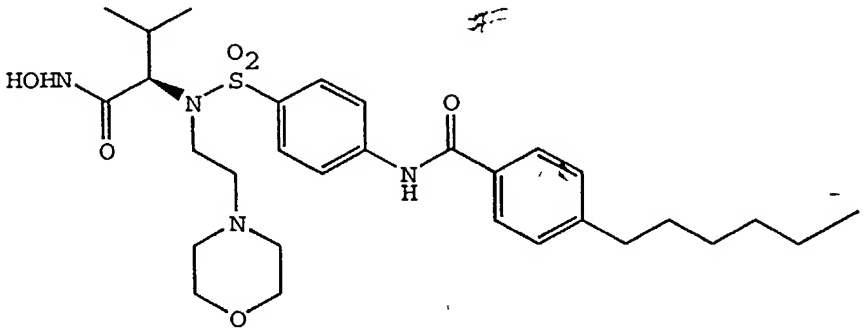
or a salt, an enantiomer, a racemate, or a tautomer thereof.

53. The method of claim 51 wherein the compound has the structure:



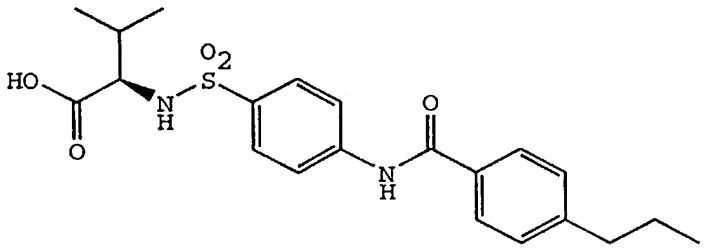
or a salt, an enantiomer, a racemate, or a tautomer thereof.

54. The method of claim 51 wherein the compound has the structure:



or a salt, an enantiomer, a racemate, or a tautomer thereof.

55. The method of claim 51 wherein the compound has the structure:



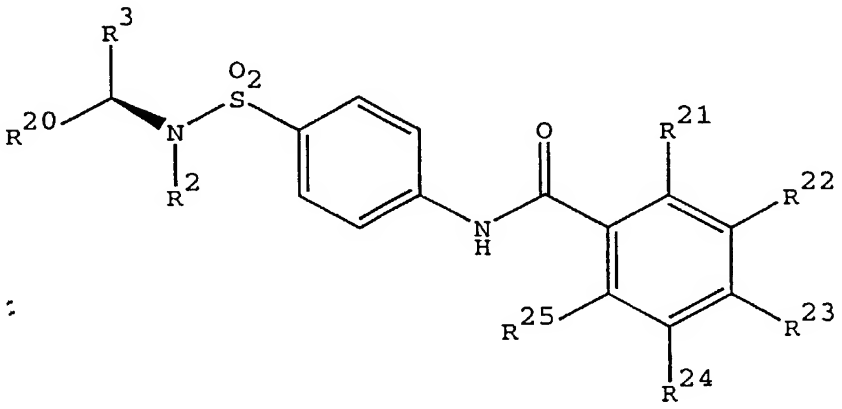
or a salt, an enantiomer, a racemate, or a tautomer thereof.

56. The method of claim 39 wherein the matrix metalloproteinase is selected from the group consisting of MMP-8 and MMP-13.

57. The method of claim 56 wherein the matrix metalloproteinase is MMP-8.

58. The method of claim 56 wherein the matrix metalloproteinase is MMP-13.

59. A method treating osteoarthritis in a mammal wherein the method comprises providing to the mammal an osteoarthritis-treating-effective amount of a compound having the formula:



or an enantiomer, diastereomer, racemate, or tautomer thereof, thereby treating osteoarthritis, wherein:

R^2 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, and heterocycloalkylalkyl;

R^3 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, haloalkoxy, haloalkylthio, and heterocycloalkyl;

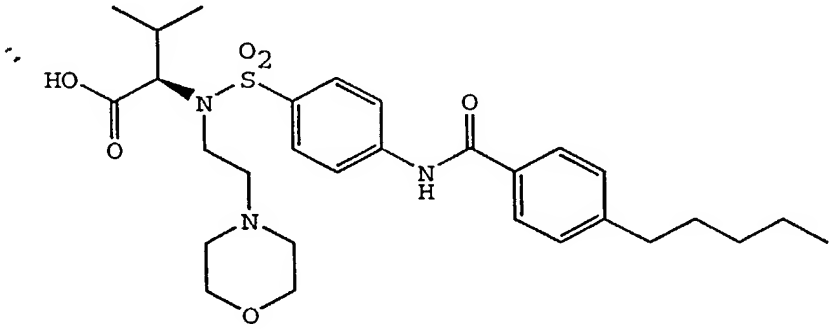
R^{20} is selected from the group consisting of -C(O)OH, -C(O)NHOH, -SH, and -C(O)SH; and

R^{21}, R^{22}, R^{23}, R^{24}, and R^{25} are independently selected from the group consisting of H, C_1 to about C_{20} alkyl, C_1 to about C_{20} alkenyl, C_1 to about C_{20} alkynyl, cycloalkyl, haloalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl,

alkylaminoalkyl, nitroalkyl, heterocycloalkyl, alkoxy, cycloalkoxy, alkoxycarbonyl, alkoxyalkyl, haloalkoxy, haloalkylthio, alkylamino, and carboxyalkyl.

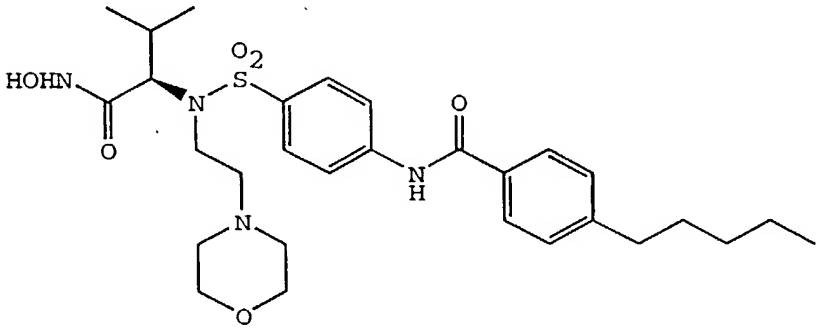
60. The method of claim 59 wherein the mammal is a human.

61. The method of claim 60 wherein the compound has the structure:



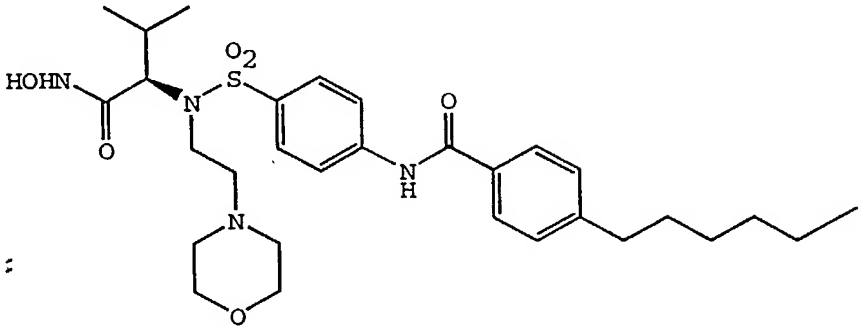
or a salt, an enantiomer, a racemate, or a tautomer thereof.

62. The method of claim 60 wherein the compound has the structure:



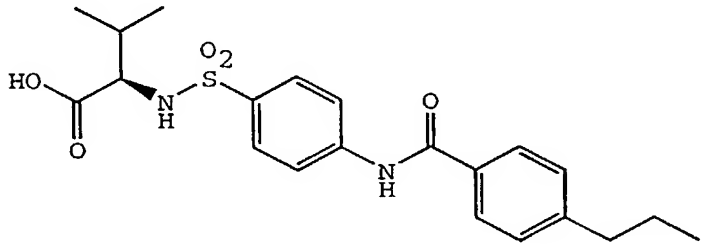
or a salt, an enantiomer, a racemate, or a tautomer thereof.

63. The method of claim 60 wherein the compound has the structure:



or a salt, an enantiomer, a racemate, or a tautomer thereof.

64. The method of claim 60 wherein the compound has the structure:



or a salt, an enantiomer, a racemate, or a tautomer thereof.

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(74) Agents: **WARNER, James, M.** et al.; G.D. Searle & Co., Corporate Patent Department, P.O. Box 5110, Chicago, IL 60680-5110 (US).

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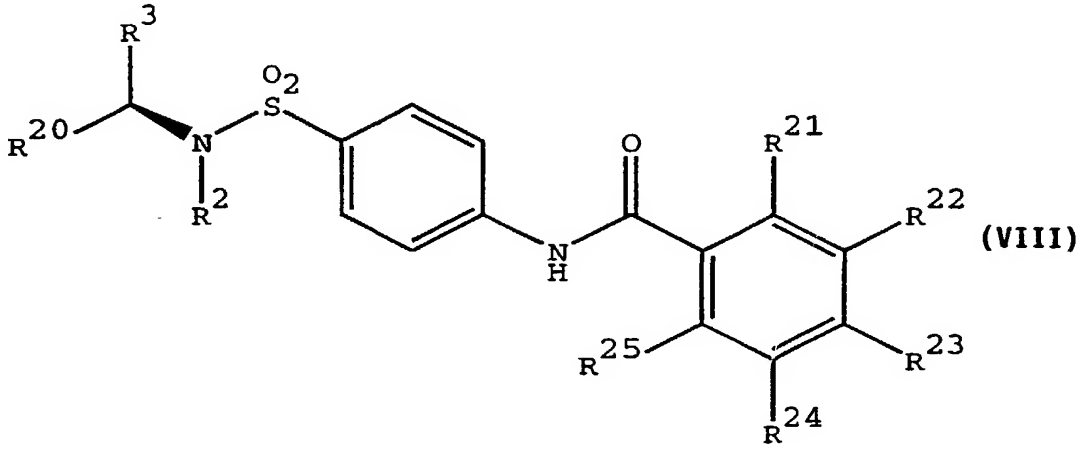
(54) Title: N-SULFONYLAMINIACID DERIVATIVES AS INHIBITORS OF METALLOPRTEINASE



(VIII)

(57) Abstract: The present invention provides a matrix metalloproteinase inhibiting compound having structure (VIII) or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof. In other embodiments, the present invention provides a method of changing the conformation of a matrix metalloproteinase, a method of inhibiting a matrix metalloproteinase, and a method of treating osteoarthritis.

WO 01/05389 A3

Figure 1

Sequence Alignment for mmp-8, mmp-3, and mmp-1

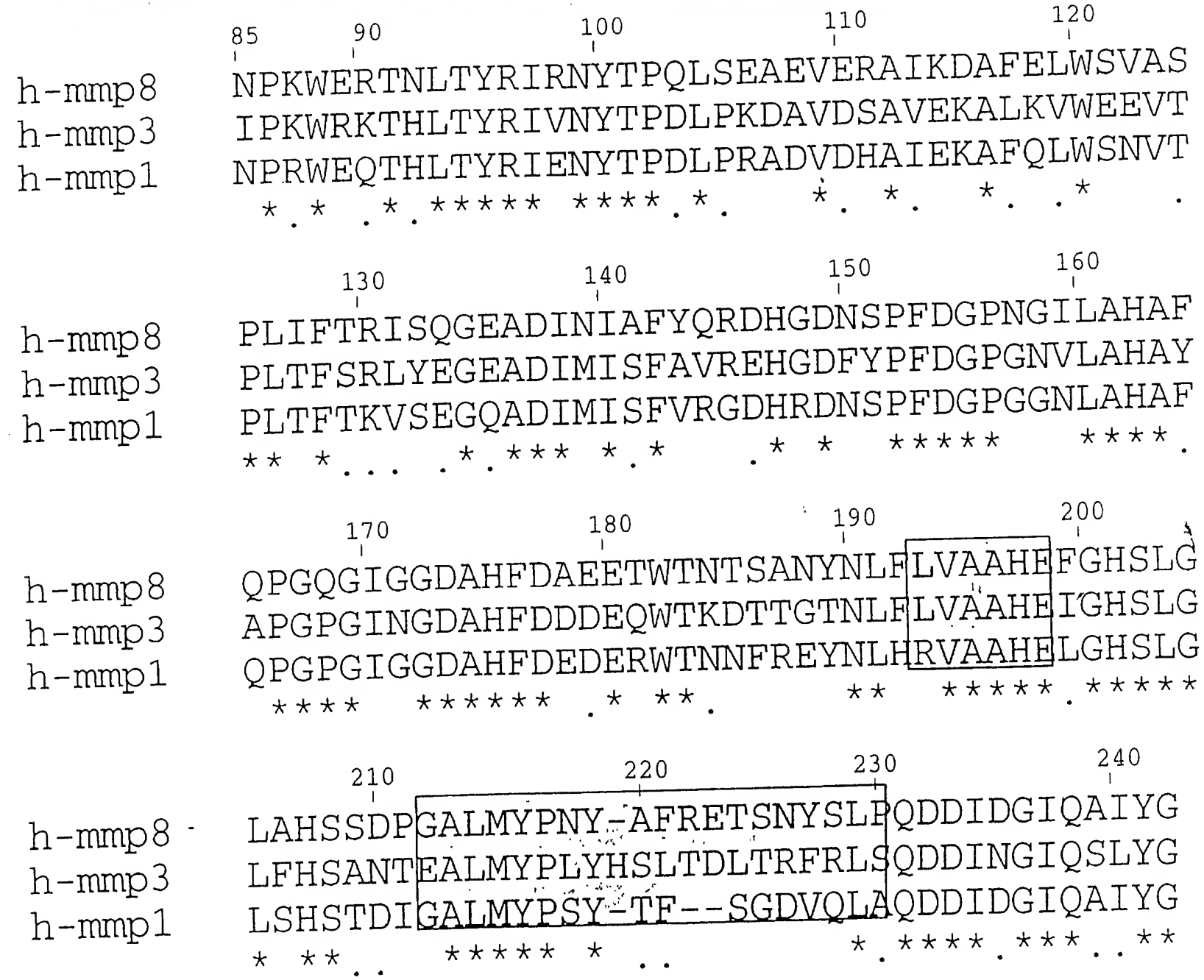


Figure 2

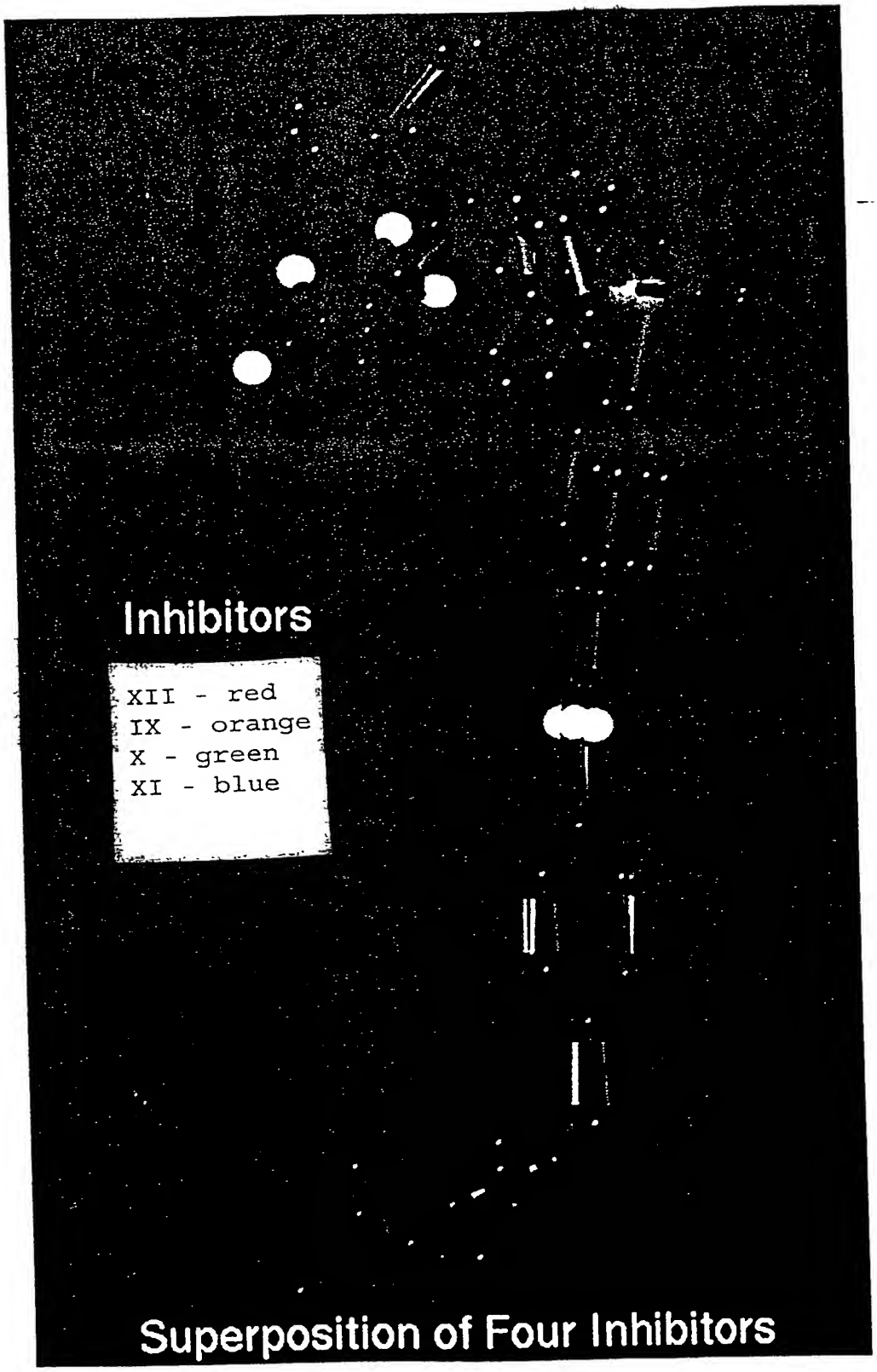

Inhibitors
XII - red
IX - orange
X - green
XI - blue
Superposition of Four Inhibitors

Figure 3

Interacting Residues Within 5 A of the Inhibitor Molecule							
		XII	IX	X	XI	XIV	
	L119	no				no	
	G158						
	I159						
	L160						
	A161						
	H162						
	A163	no					
	L193						
	V194						
	A196	no	no		no	no	
	H197						
	E198						
	H201						
	H207						
	G212		no	no		no	
	A213						
	L214						
	Y216						
	P217						
	N218						
	Y219						
	A220						
	R222						
	T224	no				no	
	Y227		no	no	no	no	
	S228	no				no	
	P230					no	

Figure 4

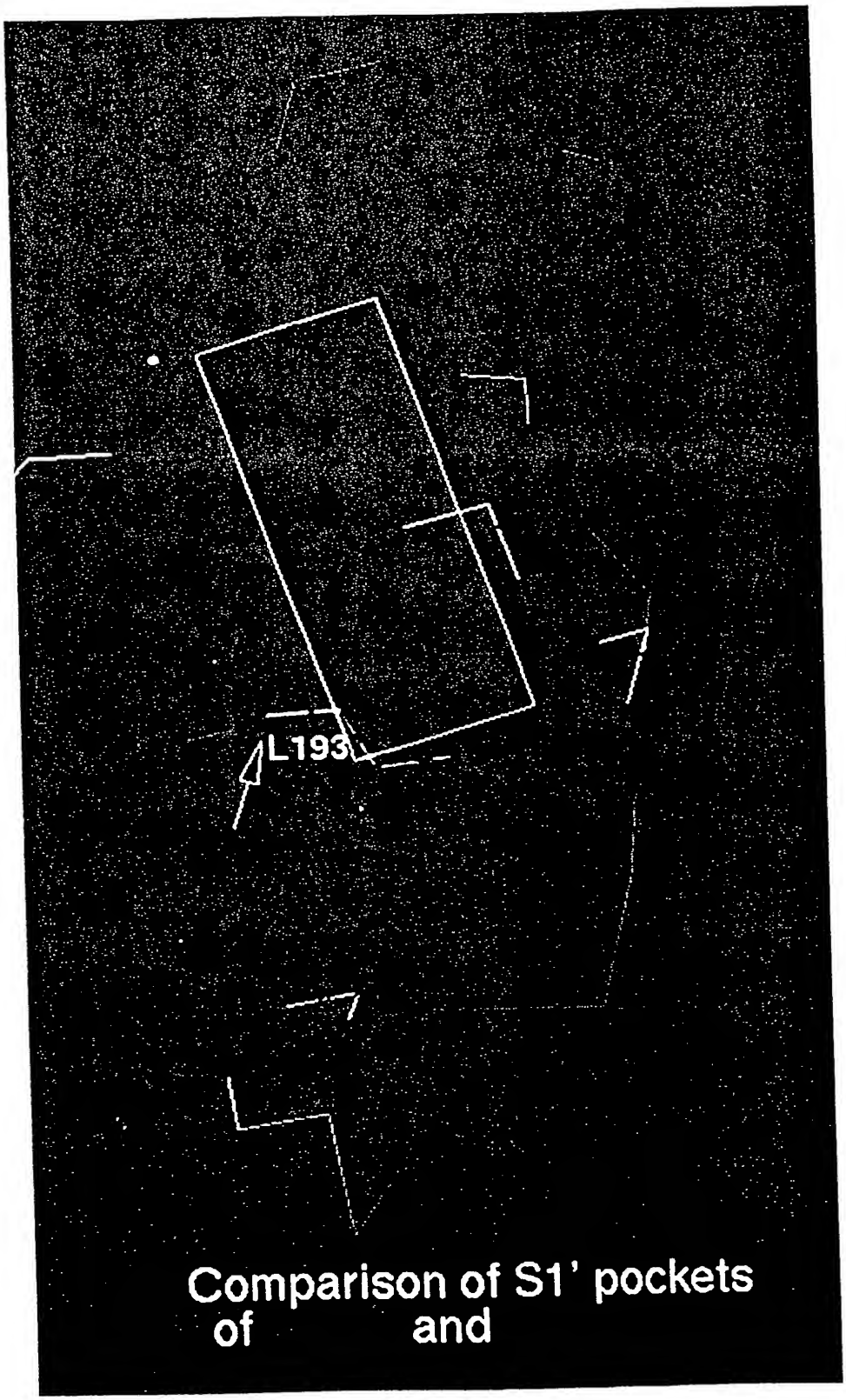


Figure 5

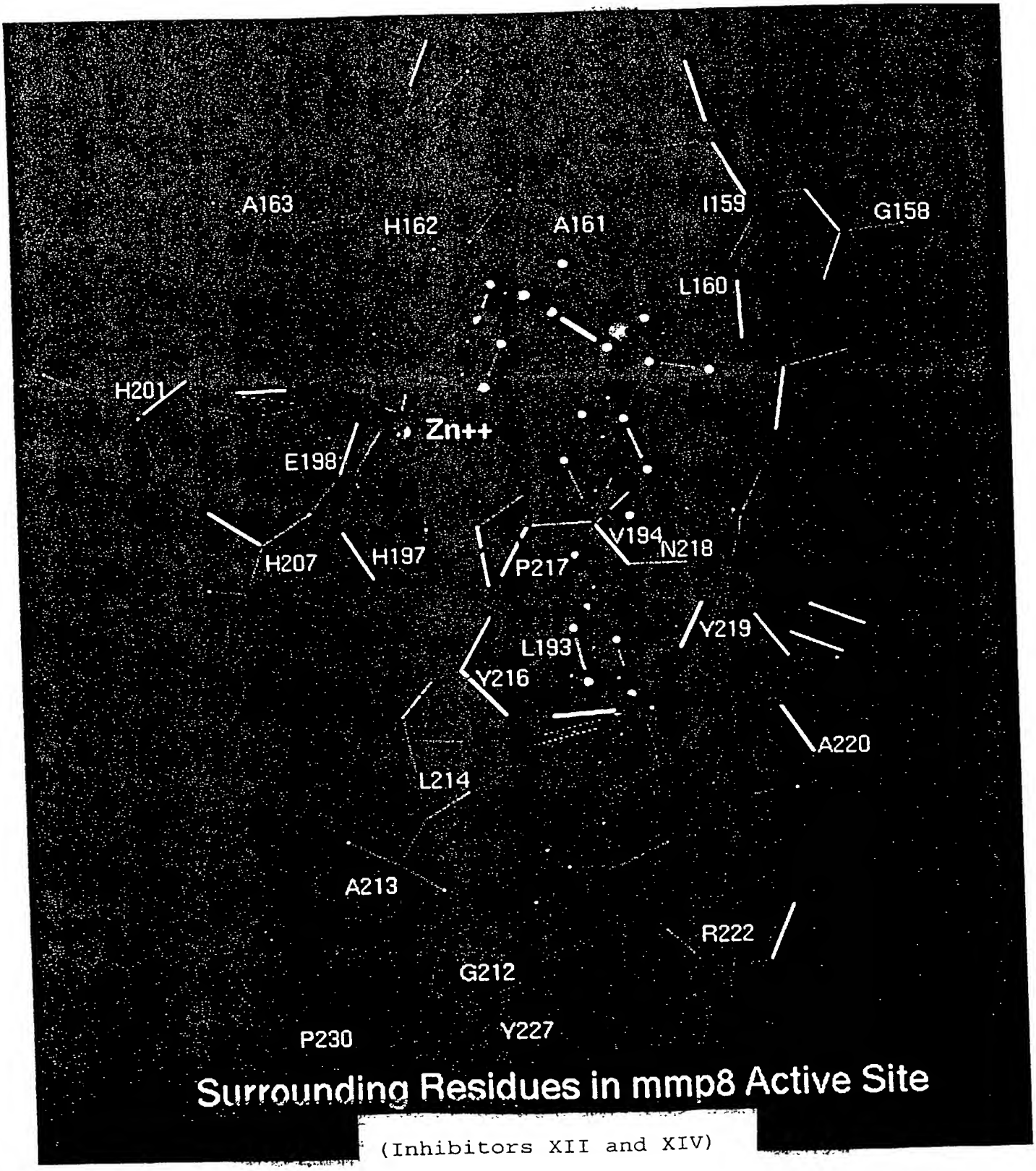
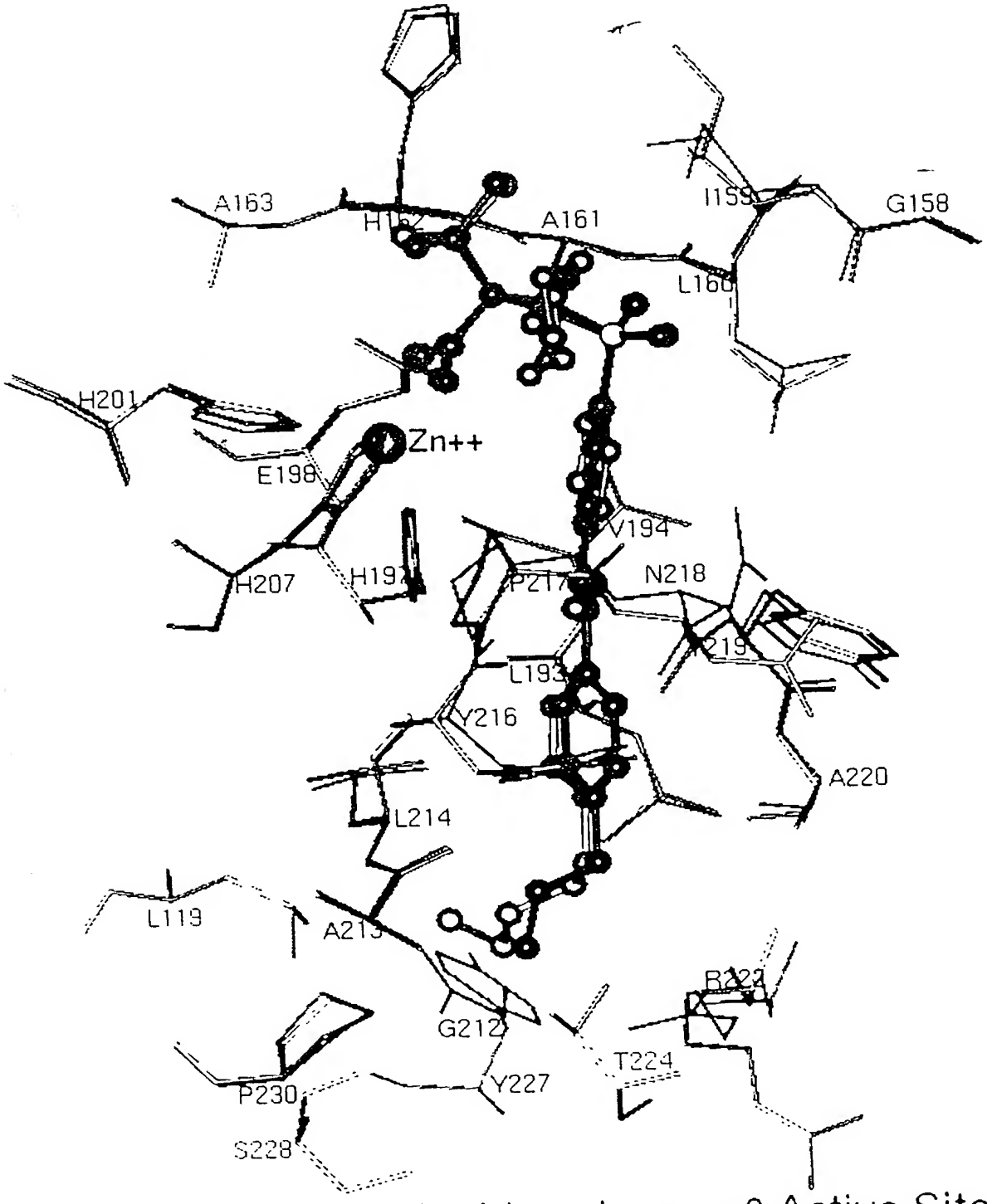
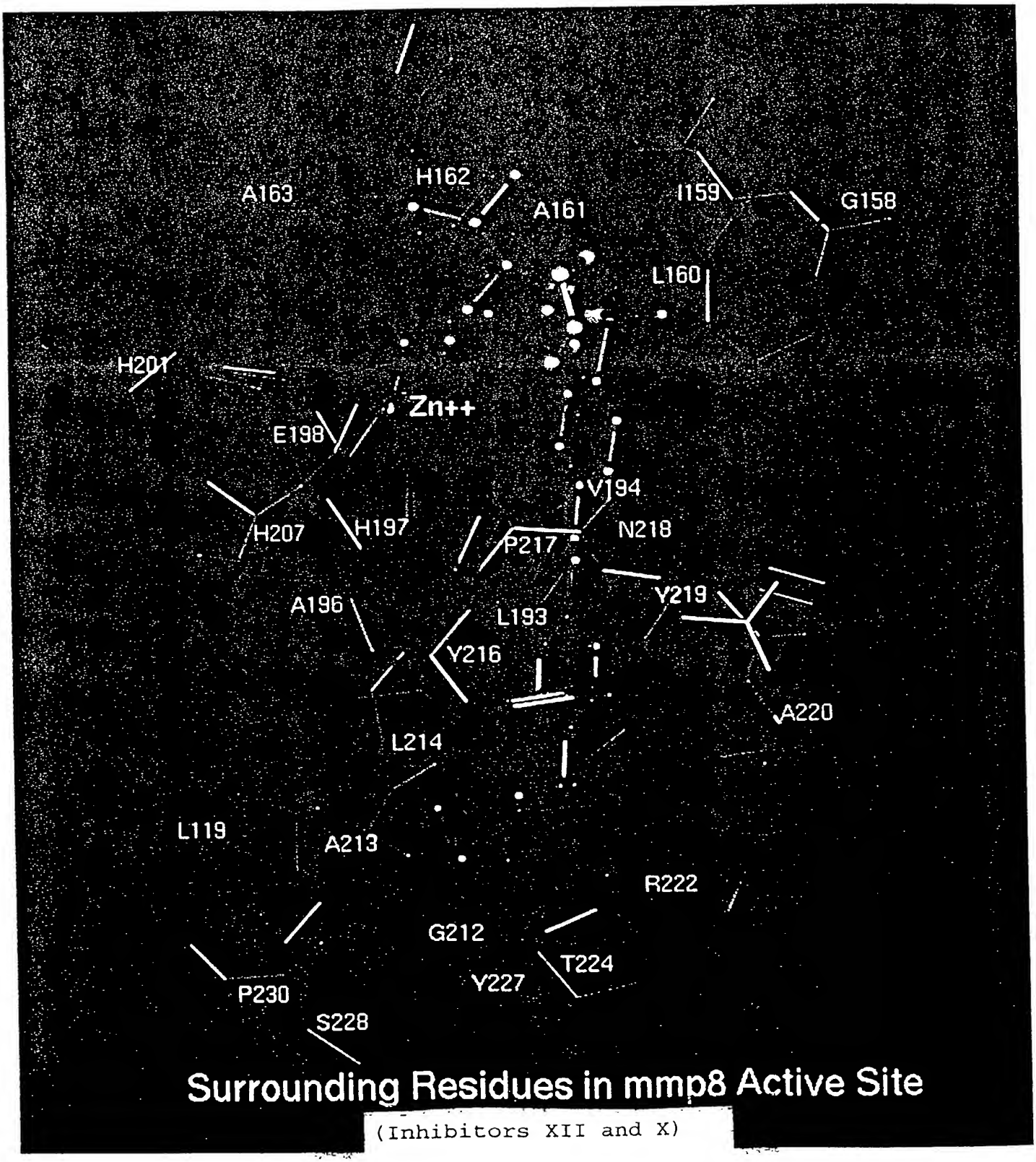

A163
H162
A161
I159
G158
L160
H201
Zn++
E198
V194
N218
H207
H197
P217
Y219
L193
Y216
A220
L214
A213
R222
G212
P230
Y227
Surrounding Residues in mmp8 Active Site
(Inhibitors XII and XIV)

Figure 6



Surrounding Residues in mmp8 Active Site

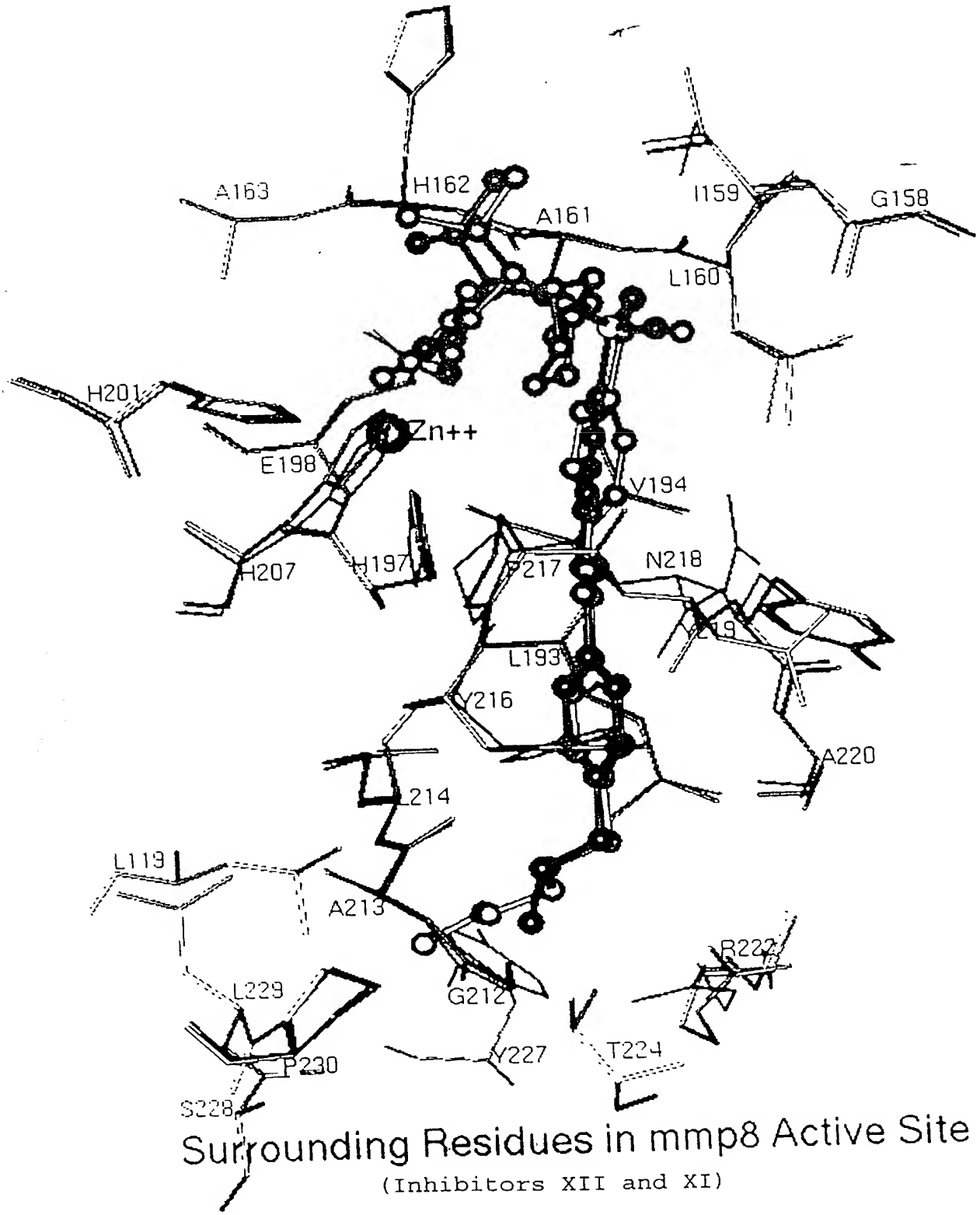
(Inhibitors XII and IX)



Surrounding Residues in mmp8 Active Site

(Inhibitors XII and X)

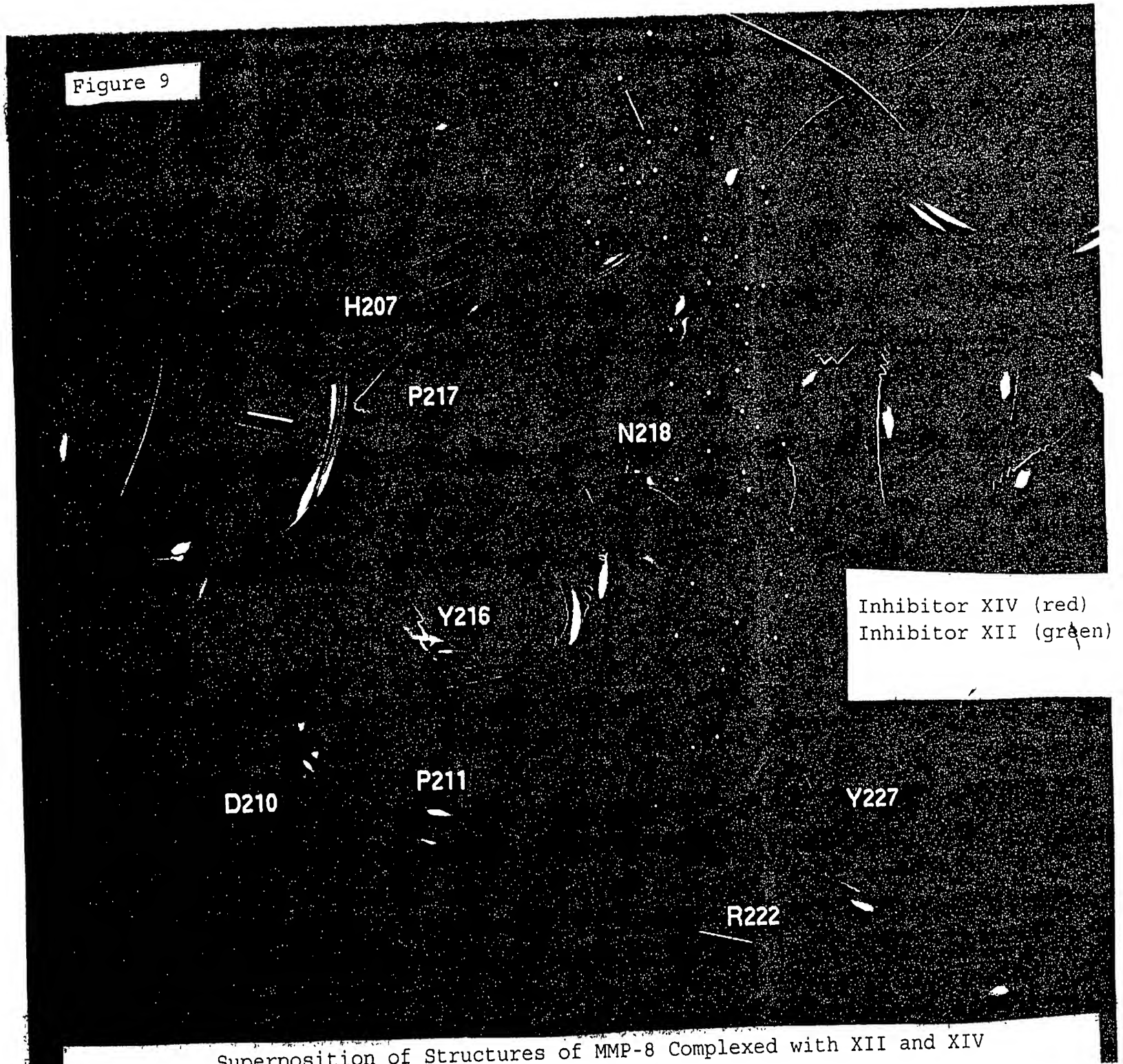
Figure 8



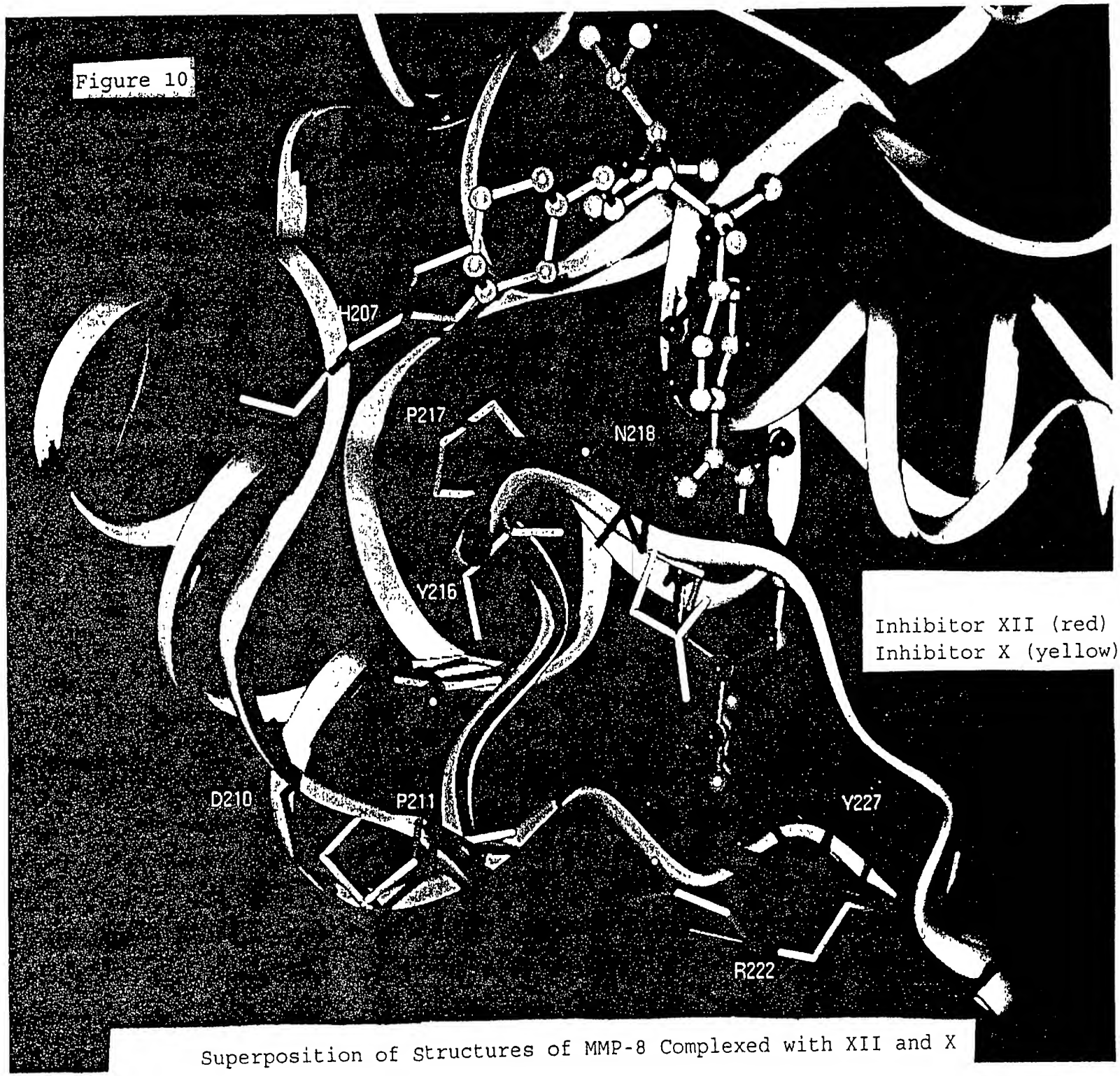
Surrounding Residues in mmp8 Active Site

(Inhibitors XII and XI)

Figure 9

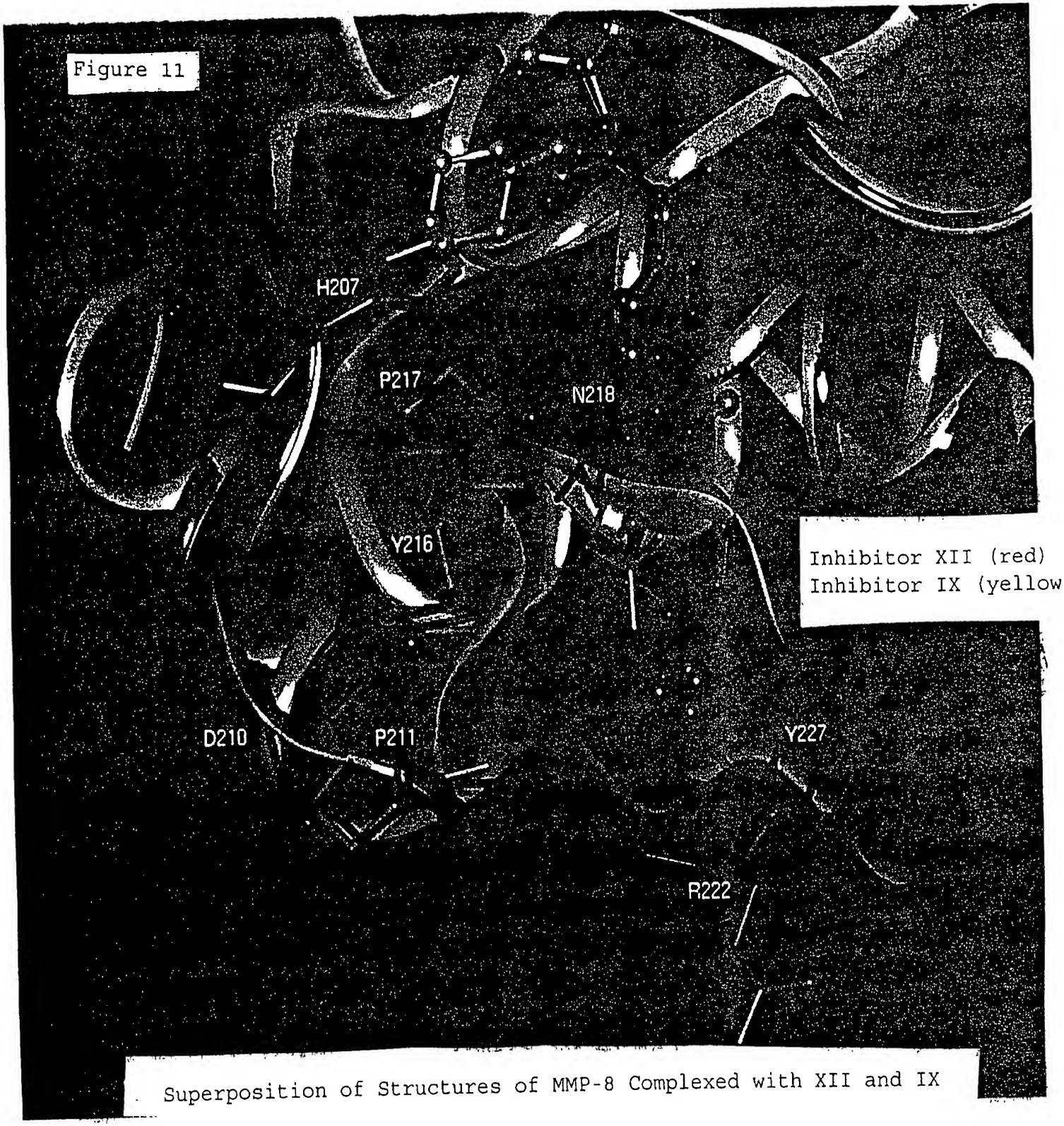


Superposition of Structures of MMP-8 Complexed with XII and XIV



Superposition of Structures of MMP-8 Complexed with XII and X

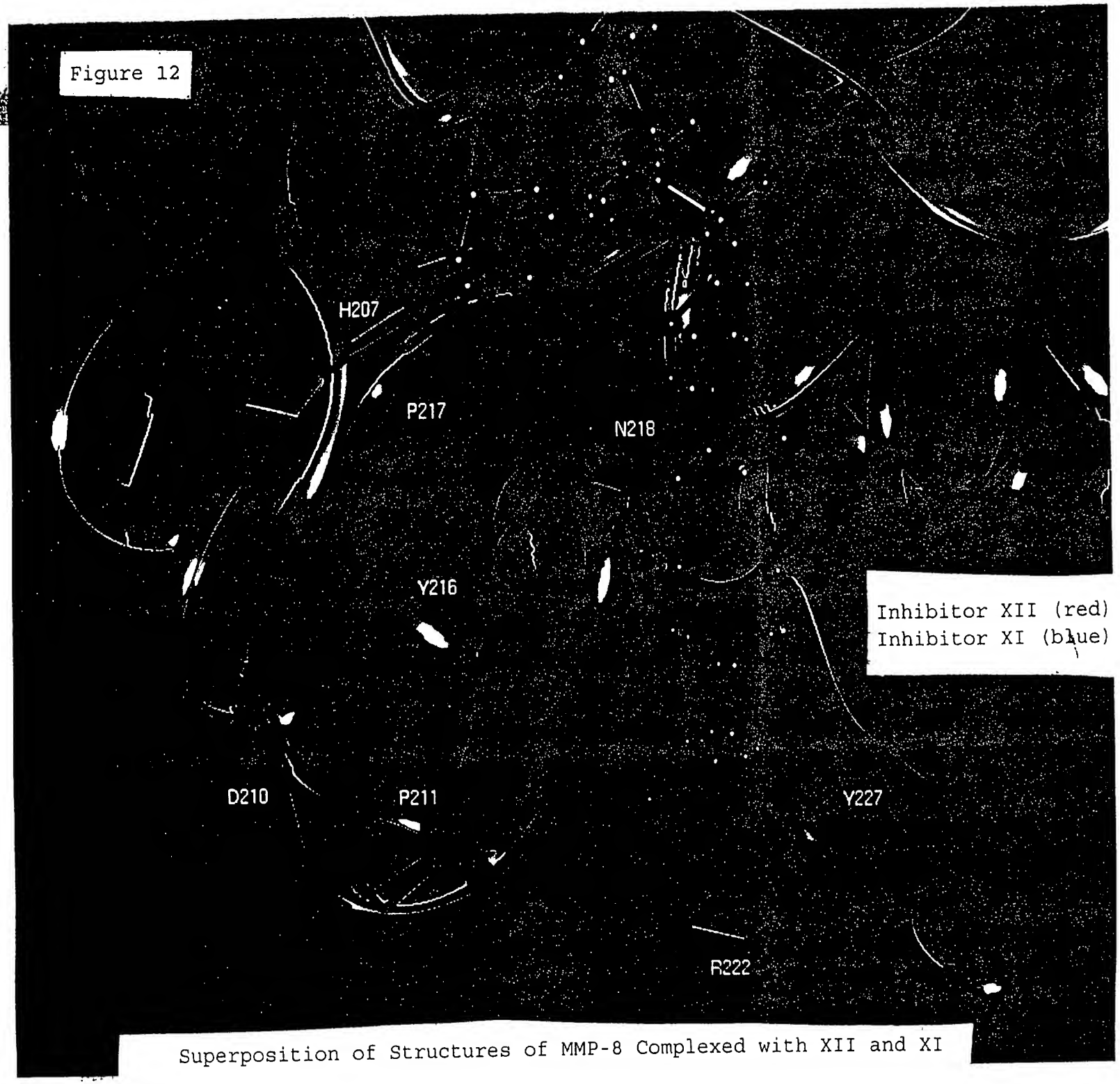
Figure 11



Inhibitor XII (red)
Inhibitor IX (yellow)

Superposition of Structures of MMP-8 Complexed with XII and IX

Figure 12



Superposition of Structures of MMP-8 Complexed with XII and XI

Figure 13

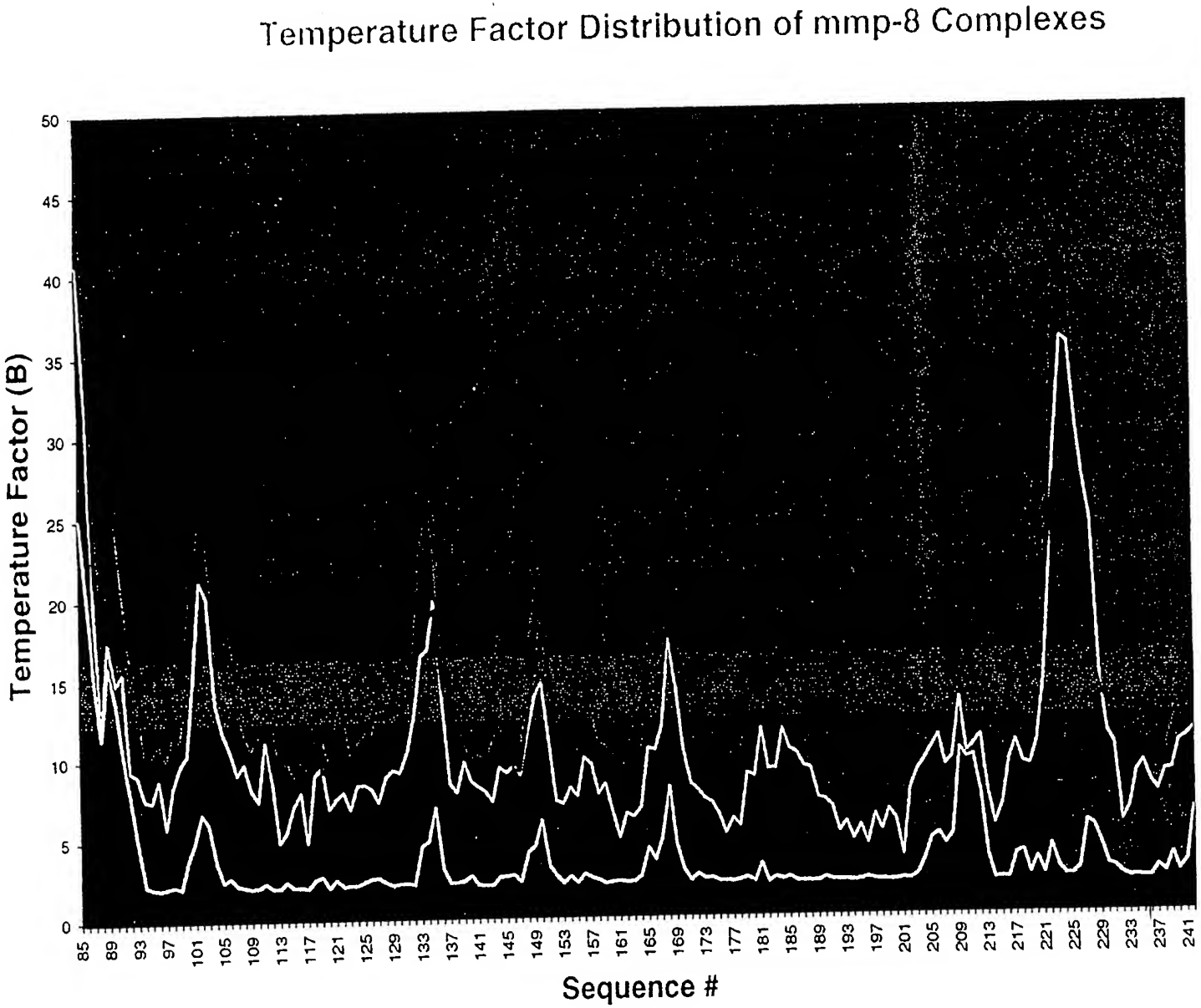


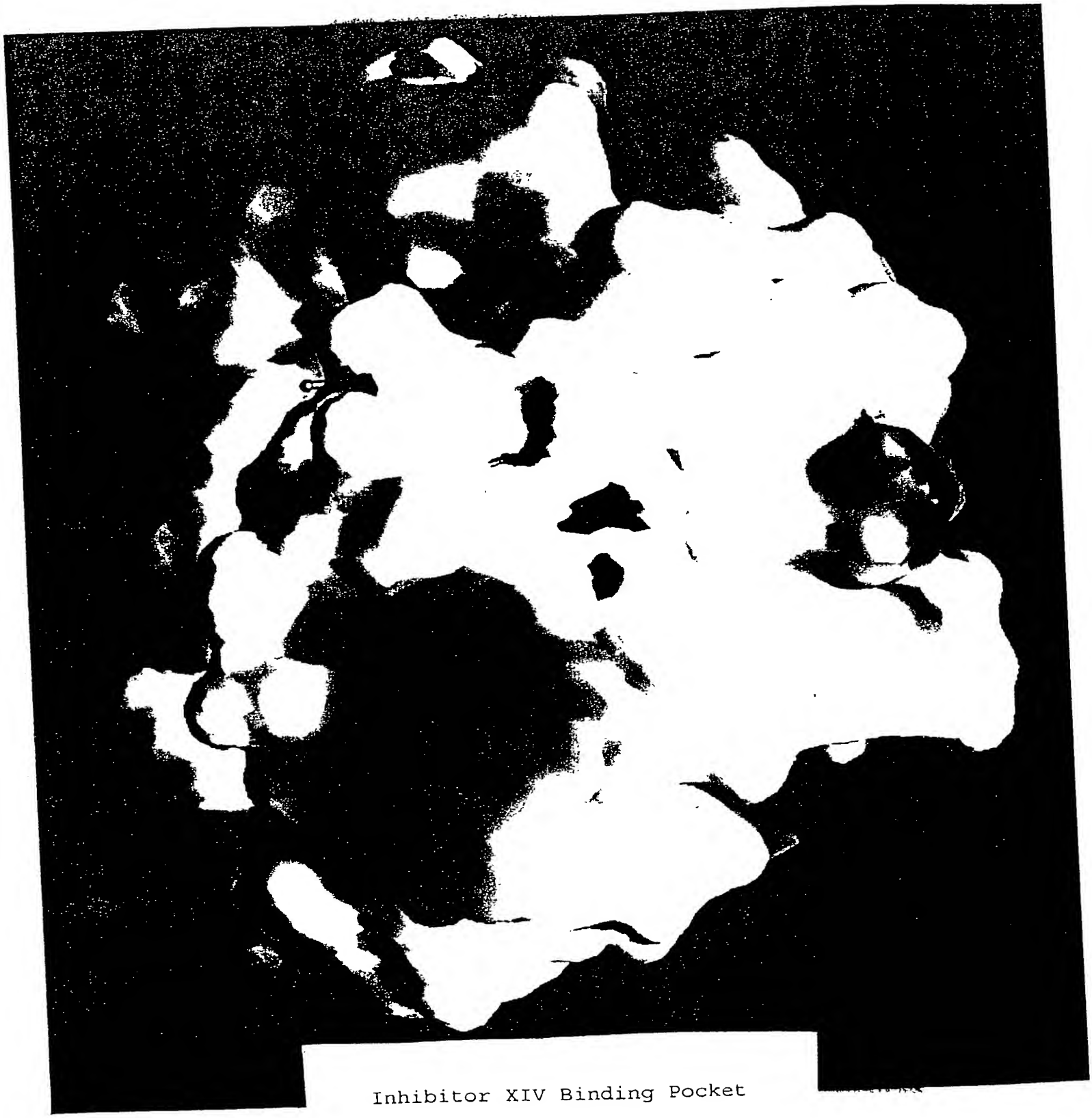
Figure 14

(ϕ, ψ) Distribution Among the Residues from 222 to 231

	222 (R)		223 (E)		224 (T)		225 (S)		226 (N)	
I	-143.1	145.4	-50.0	128.2	-102.1	-14.3	-48.1	-31.1	-147.0	43.3
II	-132.7	133.2	-76.8	126.3	-112.1	134.8	-124.7	-16.2	-145.6	-174.7
III	-154.5	134.9	-73.5	145.4	-141.2	115.8	-89.0	-23.2	-136.0	-161.4
IV	-142.1	129.3	-74.5	134.3	-125.4	149.0	-128.8	-10.4	-144.1	-168.4
X1	-151.0	145.4	-48.5	130.0	-105.1	-10.5	-55.9	-29.2	-144.8	45.9
X2	-156.8	143.9	-43.9	129.5	-108.0	-9.7	-54.9	-29.8	-145.1	40.5

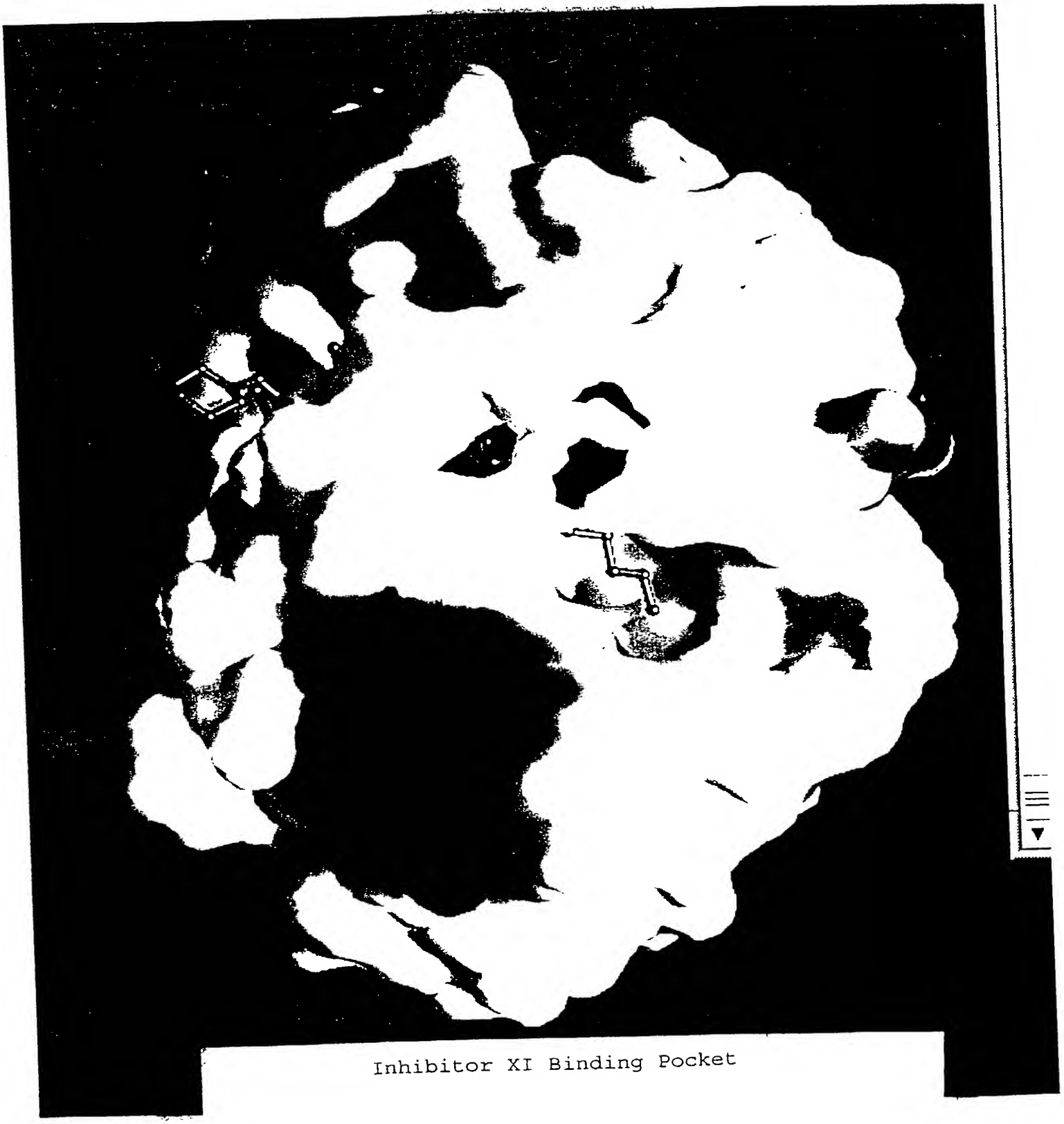
	227 (Y)		228 (S)		229 (L)		230 (P)		231 (Q)	
I	-66.4	137.6	-139.7	147.8	-48.4	124.5	-60.7	152.7	-46.1	-44.3
II	-91.6	28.1	-86.5	126.1	-96.1	149.1	-59.7	152.2	-54.4	-35.0
III	-99.2	28.6	-92.2	127.0	-90.6	149.7	-61.1	155.6	-55.0	-42.0
IV	-97.7	21.7	-85.3	128.3	-85.4	159.9	-62.8	156.6	-56.3	-40.1
X1	-74.2	143.6	-143.0	153.8	-54.7	138.0	-66.6	158.4	-46.3	-51.6
X2	-70.4	140.5	-138.9	157.2	-54.4	136.8	-67.6	157.8	-46.1	-50.5

Figure 15



Inhibitor XIV Binding Pocket

Figure 16



Inhibitor XI Binding Pocket

DECLARATION AND POWER OF ATTORNEY

Atty. Dkt. No.: 3333/1/US

DECLARATION

As a below named inventor, I hereby declare that:

My residence, mailing address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD OF CHANGING CONFORMATION OF A MATRIX METALLOPROTEINAISE

the specification of which (check one)

☒ is attached hereto.
or
☐ was filed on _____ as Application Serial No. or PCT International Application No. _____ and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. §§ 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or any PCT international application having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)				
APPN. SERIAL NO.	COUNTRY	DATE FILED (MM/DD/YYYY)	PRIORITY CLAIM Yes	PRIORITY CLAIM No
US00/16323	PCT	07/12/00	☒	☐
			☐	☐

DECLARATION AND POWER OF ATTORNEY

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below:

PRIOR PROVISIONAL APPLICATION(S)	
APPN. SERIAL NO.	DATE FILED (MM/DD/YYYY)
60/144,133	July 16, 1999

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s) listed below:

PRIOR U.S. APPLICATION(S)		
APPN. SERIAL NO.	DATE FILED (MM/DD/YYYY)	STATUS – PATENTED, PENDING, ABANDONED

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY

(22) I hereby appoint Bryan K. Wheelock, Reg. No. 31,441, Joseph E. Walsh, Jr., Reg. No. 36,959, Rudolph A. Telscher, Jr., Reg. No. 36,032, Donald Holland, Reg. No. 35,197, David M. Gryte, Reg. No. 41,809, Evan R. Sotiriou, Reg. No. 46,247, Elizabeth D. Odell, Reg. No. 39,532, Kelly K. Burris, Reg. No. 46,361, Alan Cassel, Reg. No. 35842, James L. Lindon, Reg. No. 45,498, Matthew Cutler, Reg. No. 43574, Scott Gray, Reg. No. 48891, and Anthony G. Fussner, Reg. No. 47582 of Harness, Dickey & Pierce, P.L.C., and James M. Warner, Reg. No. 45,199, S. Christopher Bauer, Reg. No. 42,307, Dennis A. Bennett, Reg. No. 34,547, Cynthia S. Kovacevic, Reg. No. 35,578, Scott A. Williams, Reg. No. 39,876, J. Timothy Keane, Reg. No. 27,808, James C. Forbes, Reg. No. 39,457, Philip Polster, Reg. No. 43,864 and Richard A. Mueller, Reg. No. 41,094 of Pharmacia Corporation (800 N. Lindbergh, St. Louis, Missouri 63167) my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

DECLARATION AND POWER OF ATTORNEY

CORRESPONDENCE ADDRESS

I request the Patent and Trademark Office to direct all correspondence and telephone calls relative to this application to:

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(314) 694-3642 (telephone)
(314) 694-9095 (facsimile)

1-00

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Inventor's signature: William C. Stallings
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Citizenship: United States
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2-00

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Inventor's signature: Huey S. Shieh
Date: Jan. 16, 2002
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Citizenship: United States
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3-00

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Mailing Address: 35 Worthy Ct, Fenton, MO 63026-2751

DECLARATION AND POWER OF ATTORNEY

4-D

Full name of fourth joint inventor: Gary A. DeCrescenzo BBCH

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Mailing Address: 7345 Spruce Hill Ct. Dardenne Prairie

5-D

Full name of fifth joint inventor: Joseph J. McDonald BBCH

Inventor's signature: Joseph J. McDonald

Date: JAN. 14, 2002

Residence: 1716 Timber Ridge Est. Dr.

Citizenship: United States

Mailing Address: 1716 Timber Ridge Est. Dr, Wildwood MO 63011 MO

United States Patent & Trademark Office

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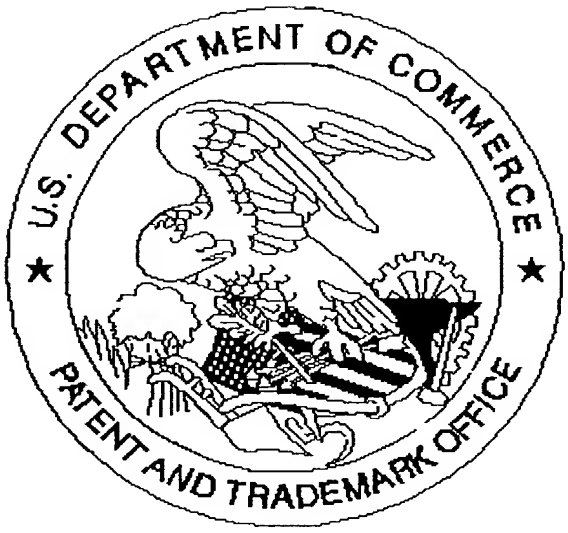

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☐ Page(s)_____ of _____ were not present for scanning. (Document title)

☐ Page(s)_____ of _____ were not present for scanning. (Document title)

☐ ***Scanned copy is best available.***

- Specification pages have a line.
- Some drawing figures are too dark.